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THE GEOLOGICAL HISTORY OF NEW YORK ISLAND AND HARBOR.

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I. NEW YORK IN ANCIENT GEOLOGICAL TIMES.—The rocks which compose New York Island and underlie the adjacent country on the north and east are chiefly gneiss and mica-schist, with heavy intercalated beds of coarse-grained, dolomitic marble and thinner layers of serpentine. These are all distinctly stratified, and have once been sedimentary beds deposited horizontally—sandstones, shales, and limestones—but now, upheaved and set on edge, are by metamorphism converted into compact crystalline strata with the obliteration of all fossils—if fossils they contained. The age of these rocks has not yet been accurately determined, although they have usually been supposed to be Lower Silurian, and a continuation of those which contain the marble-beds of Western Massachusetts and Vermont. There are some reasons, however, why they should be regarded as still older. That they do not form the southern prolongation of the marble belt of Vermont is indicated by the facts that both the marble-beds and the rocks associated with them are so unlike in the two localities that they can hardly be parts of the same formation. In Vermont, the marbles occur in what is essentially a single belt, are fine-grained, usually banded and mottled, are nearly pure carbonates of lime, and the rocks immediately associated with them are gray siliceous limestones, quartzites, and slates. In Westchester County, and on New York Island, on the contrary, the marbles are very coarsely crystalline dolomites (double carbonates of lime and magnesia), which occur in a number of parallel belts, are generally of uniform white or whitish color, and have no rocks associated with them that can represent the quartzites and argillites of Vermont. On the whole, the group of strata which forms New

York Island has so great a similarity to some portions of the Laurentian series in Canada that it is difficult to resist the conviction that they are of the same age.

The Canadian series is supposed to be not less than 50,000 feet in thickness, consisting of somewhat different elements in different parts, but mainly of gneiss and crystalline schists with numerous beds of dolomitic marble and serpentine, and containing, as most characteristic minerals, magnetic iron-ore and apatite (phosphate of lime). The beds stand at a high angle, and, although having once formed great folds and even mountains, by ages of surface-erosion they have been worn down to a merely undulating surface. On the east bank of the Hudson, at and above New York, we have almost precisely the same state of things, viz.: 1. A belt of crystalline rocks forming apparently a continuous series to and beyond the Connecticut line; 2. Strata set nearly vertical, once forming high hills or mountains, now worn down by long exposure to a mere rolling surface; 3. The series composed chiefly of gneiss and crystalline schists, with heavy beds of dolomitic marble and thinner bands of serpentine; and, 4. Containing in its western portion where it joins the New Jersey iron belt—with which it is inseparably connected—important beds of magnetic iron-ore, while apatite is one of the most common disseminated minerals. From these and other reasons which might be mentioned, the New York rocks are regarded by the writer as of Laurentian age. They seem to have formed a ridge which was a part of a range of highlands that ran down on the eastern side of our continent, having the same general direction with the Alleghanies, but being very much older than the more recent folds of that chain. Indeed, judging from the character of the rocks composing it, the immense amount of surface-erosion it has suffered, and the absence of overlying strata, we must regard it as one of the oldest portions of the continent.

Staten Island is in part a continuation of the New York belt of Laurentian rocks—the eastern side being composed of granite and serpentine, the western of trap and Triassic sandstone—and owes its relief to that fact. South of this point the ridge sinks down and is covered

Profile Section from the Hudson to the Connecticut.

Fig. 1.

with more recent strata, but it apparently reappears at Trenton and Philadelphia. Thus it would seem to be a sort of spur of the Blue Ridge, the oldest chain of the Alleghany belt, diverging from it in Fulton County, New York, and following a nearly parallel course southwestward.

During the Palæozoic ages, the New York ridge seems to have been a land-surface; for the Silurian, Devonian, and Carboniferous rocks were deposited on both sides of it in New England, New York, and Pennsylvania, but no traces of them have been found upon it. In each of these ages the sea flowed in over some portion of the continent, and deposited on the inundated surfaces sediments containing more or less complete representatives of the prevalent forms of life; and these, now fossilized, afford means for identifying and classifying the strata.

In the Cambrian age the continent, composed of Laurentian and Huronian rocks, was broad and high, and the Cambrian strata (Acadian group) were deposited only along its margin.

At the beginning of the Silurian age the sea rose over its shores, covering most of the land-surface, but leaving the Canadian highlands, the Adirondacks, the Blue Ridge, with its New York spur, unsubmerged. Then during all the thousands of years in which the Trenton limestone group was accumulating by organic agencies, the slow growth and deposition after death of the hard parts of animals, and the other thousands of years in which the Hudson River and Utica shales were formed in a shallowing sea, this old land was exposed to wear from rain and wind, sun and frost.

In like manner when the Upper Silurian and Devonian seas in turn flooded more limited portions of the adjacent lands, covering them with new layers of sediment, the old ridges and highlands which have been enumerated, with large additions to their areas made in the Silurian age, were suffering constant abrasion and reduction of altitude.

In the Carboniferous age all the country for a great distance east, north, and west of New York, was above the sea, but along the coast in Rhode Island and Eastern Massachusetts were marshes where a luxuriant vegetation was forming peat-beds that were destined, in after-times, to become seams of coal; and in Pennsylvania, and thence westward in Ohio and Illinois, were vast tracts of swamp—half water, half land—which are now the most extensive coal-basins in the world. During all these ages the belt of highlands which separates the valley of the Hudson from that of the Connecticut was probably much higher than now, and stood as a witness of the varying phases of the unending war between land and sea, and saw the continent created and destroyed again and again; but in all these changes it took no part.

In the latter part of the Carboniferous age the Alleghanies proper were gradually elevated, the convex folds forming mountain-ridges, the depressed or synclinal arches becoming the slowly-deepening coal-basins. In the end all the country between the Atlantic and the Mississippi stood as a broad and elevated continental area. Subsequently the sea rose and fell upon its margin, leaving there the record of its oscillations in the deposits of the recent geological ages, but no considerable portion of its surface has since been submerged.

The Triassic age was a stormy one in the region about New York.

The trough between the New York axis and the Blue Ridge was occupied by water, and in this trough the Triassic shales and sandstones were deposited. A similar trough east of New York, where now is the valley of the Connecticut, was also a lagoon or estuary in which similar sediments accumulated, but not so quietly as the strata composing the older formations in the same region were laid down. It is evident that Nature's forces were in great activity during the period under consideration, for we find the greatest diversity in the product of these forces. The Triassic beds consist of shales, sandstones, and conglomerates. Of these the shales accumulated in comparatively clear and quiet water; and at various levels we find them filled with the remains of fishes that inhabited the lagoons where they were deposited. These fishes occur in thousands, confined to layers a few inches thick, mostly complete and mature individuals, showing that they were killed suddenly by some poisoning of the water in which they lived, its complete withdrawal, or a substitution of fresh for salt, or *vice versa*. These fish-bearing shales alternate with conglomerates that are sometimes beds of large bowlders—the result of violent water-action along a shore—or with strata of ripple-marked, sun-cracked sandstone, pitted with the impressions of rain-drops, and bearing the footprints of thousands of animals, great and small, which made these mud-banks their feeding-grounds. Here and there we find twigs of coniferous trees of the Araucarian family, or fragments of the fronds of cycads and ferns; much more frequently casts of the trunks and branches of trees mingled pell-mell, and evidently collections of drift-wood.

The footprints referred to above are generally three-toed, and resemble the tracks of birds. In dimension they vary from one to twenty inches long, and are supposed to have been made by a peculiar group of biped, birdlike reptiles, which possessed the world in Mesozoic times, and inhabited the shores of North America in great numbers during the Triassic age.

The alternations of coarse and fine strata, with their characteristic fishes and footprints, are repeated in the Trias on the west side of the Hudson until they form a series which has a thickness of several thousand feet. As the ripple-marks, sun-cracks, and other evidences of exposure to the air, occur at several levels, they prove the gradual subsidence of the trough where those sediments accumulated, with which the filling from the wash of the land kept pace, affording a succession of fresh surfaces where the winds and waves as well as living creatures left their autographs. Although as yet but partially examined and imperfectly read, these records, like the Assyrian tablets, have told us many interesting things, and they constitute a treasury of ancient lore which is destined for ages to supply new material for the geological history of this region.

From what we have already learned of the circumstances in which the Triassic rocks of our neighborhood were formed, we may conclude

that a depressed area once existed between the New York ridge and the New Jersey highlands, and that this trough was an estuary swept by the tides, much like the Bay of Fundy. Here, as there, the shallows and mud-flats exposed by the ebb were places of resort for many of the animals inhabiting the district; but there is this difference, that in the lapse of time the fauna of the country has completely changed, and the fishes which inhabited the waters of the Triassic estuary, as well as the reptilian monsters that perambulated its shores, have now utterly disappeared from the face of the earth.

The fishes of the Trias, being found at various localities both in New Jersey and the Connecticut Valley, early attracted attention, and many of them were described by Mr. W. C. Redfield—for many years a leading scientist of New York. More recently large collections of them have been made by the writer, so that now they are pretty well known. They form some twenty species of four genera—all ganoids—related to the *Lepidosteus* and *Amia* of our interior lakes and rivers.

Of the molluscous life of the age in this region we know almost nothing, since the marine deposits which contain its remains are not now above the ocean-level, and the fresh-water and estuary beds exposed to our observation have yet yielded none. Of the land-animals scarcely any traces have been found except their footprints. These prove that a motley crowd of reptiles and amphibians, some of huge size, and, according to our notions, of uncouth and hideous shapes, thronged the shores of our Triassic bay in such numbers, so swift and so well armed for attack and defense, that this must have been anything but a congenial place of residence for a peaceably-disposed citizen.

The hills which overlooked the Triassic lagoons—as they now do their exposed beds, the plains of New Jersey—were covered with forests of Araucarian pines, and the lowlands with thickets of sago-palms and ferns, while gigantic scouring rushes lined the marshy shores. There were no oaks, maples, nor walnuts in the forests, and probably no flower-bearing shrubs or herbs in the undergrowth, for nearly all the fruits and flowers belong to the angiosperms and palms, neither of which had yet made their appearance on the earth's surface. Hence, the vegetation must have been sombre and uninteresting, compared with that of the present day, and, as there were no grasses in it, ill-adapted to the wants of man or the higher animals.

At the close of the Triassic age this region became the scene of great and destructive physical changes, which must have completely altered its aspect. Along the Triassic belt, both east and west, subsidences took place, or displacements by lateral pressure which tilted up all the strata until they stood at an angle with the horizon of 15°, where they still remain—those on the east dipping eastward, those of New Jersey toward the west. At the same time deep fractures reached the source of molten matter below, and this was forced up, either in dikes through vertical fissures, or in sheets between the beds of the

stratified rocks. Cooling in place, these trap-sheets are now conformable to the associated strata, and seem at first sight to be normal portions of it, but the metamorphism which they have produced in the beds above and below them show that they are intrusive. The erosion which has since acted upon the surface of this region has cut away the softer sandstones and shales, leaving the outcropping edges of the trap-sheets in high-relief, and these are now known as the Palisade Range, First and Second Newark Mountains, etc.

It has been suggested that the New Jersey and Connecticut basins were once connected by strata which occupied all the interval between them, and that by the subsidence of the sides or the elevation of the central portion an arch was formed the crown of which has been removed by erosion. It seems, however, scarcely probable that some thousands of feet of Triassic rocks, including thick beds of hard and resistant trap, should have been so completely carried away from the interval of 100 miles now separating the Triassic basins, that not a trace of them should be anywhere left. There is apparently good evidence also that the trap-sheets of the Connecticut Valley issued from fissures there, and appertained to a distinct line of disturbance; and, further, that the materials composing the Triassic series in each belt were derived from the adjacent highlands, and were spread by currents which swept up and down two narrow troughs.

To some persons, the most interesting fact in regard to the Trias yet remains to be mentioned, and this is that from the quarries sunk in its sandstone-beds—of which the most important are at Bellville, New Jersey, and Portland, Connecticut—has been taken the brown-stone to which we owe the architectural beauty and monotony of the best portions of our city. Copper is also frequently found impregnating the Triassic rocks, but it has generally proved only a snare to those who have attempted to work it, the deposit being small and unreliable.

PROFILE SECTION FROM TROWBRIDGE MT. TO THE HUDSON RIVER.

FIG. 2.

During the time in which the Jurassic rocks were deposited in other places, the Atlantic coast of North America seems to have been above the sea-level, for we find here no strata which are certainly of that age. Some writers have called *Jura-Trias* the beds described as Triassic on the preceding pages, but up to the present time no facts have been brought to light which justify this usage. Possibly the uppermost beds of the series may hereafter be found to contain Jurassic fossils,

but none such have yet been discovered, while a number of well-known European Triassic species have been obtained from what are considered as the highest portions of the group in Virginia and North Carolina.

In the Cretaceous age the region about New York sunk below its Triassic level, and the sea came in over a belt of country which was before, and is now, dry land. The waves in their advance cut away much of the shore which opposed their progress, both rock and soil, and spread a sheet of sea-beach composed of gravel and sand as far as they reached inland. This old beach we now know as the *Raritan sands*, and they contain great quantities of leaves, branches, and trunks of trees, which had grown on the sinking coast. On examination, they prove to be entirely different from those contained in the Triassic rocks, consisting mainly of the remains of angiospermous plants—the highest botanical group, and such as form the prevailing vegetation of the present day. Among these Cretaceous plants we find the leaves of oaks, magnolias, and other genera now living in our forests. These prove that, in the long interval—the Jurassic age—which intervened between the Triassic and Cretaceous, the vegetation of the world had been completely revolutionized; at least, that most of the genera and species which prevailed during the Triassic age had passed away, and been superseded by such as had been before unknown.

When the water stood at a moderate depth over the sunken shore, the *Amboy clays* settled down upon the sandy bottom. These were apparently derived from the feldspar of the granites which compose the neighboring highlands; the quartz, unaffected by chemical action, and less finely comminuted, remaining as sand and gravel nearer its place of origin.

As the water deepened, true marine conditions supervened along the coast, and the first two of the New Jersey *marl-beds* were formed from the remains of animals which inhabited the sea, and such as were washed into it from the adjacent shore. The green-sand of these marl-beds is derived chiefly from the countless number of microscopic shells of the *Foraminifera*, which filled the waters of the Cretaceous sea here, as in many other places. Its green color is due to *glauconite*, a silicate of lime, potash, alumina, etc. White chalk is likewise composed chiefly of the shells of *Foraminifera*, but these lived in deeper water, and were of different kinds from those that produced the green-sand. The fertilizing property of the marls is due to the potash and phosphorus they contain.

The marl-beds are also vast cemeteries, in which are stored the more or less perfect remains of the larger land and water animals of Cretaceous times. Among these we find the shells of Ammonites—the great coiled cephalopods—and a large number of other mollusks characteristic of the Cretaceous fauna. There have likewise been discovered in the marl-beds numerous remains of large reptiles, both herbivorous and carnivorous. Among these are *Hadrosaurus* and *Lælaps*—the represent-

atives of *Iguanodon* and *Megalosaurus* of the Old World—*Mosasaurus*, and many others. *Hadrosaurus* was herbivorous, while *Lælaps* was a carnivore. Both were biped, terrestrial reptiles, thirty feet long, standing fifteen to twenty feet high, and of very peculiar and interesting structure. The former will be remembered as that of which the spirited restoration, made by Prof. Hawkins for the Central Park, was destroyed by the order of Judge Hilton. *Mosasaurus* was a snake-like, marine lizard, some sixty or seventy feet long, and of pronounced carnivorous habits. These, with their associates, probably densely populated the land and sea, while the air was the special domain of the huge flying dragons—the pterodactyls. With such a numerous and so enterprising a population, it is evident that life in this time and region was full of variety.

At the close of the Cretaceous age the animal life, both sea and land, was again revolutionized, but by causes which we cannot yet fully understand, as the physical conditions remain nearly the same, and the flora suffered little change. The facts, however, are unquestionable. All the great reptilian fauna disappeared as if by magic, and gave place to herds of mammals, numerous and large it is true, but far inferior in size and armament to their predecessors. In the sea, the whole Ammonite family disappeared at once, and other great changes took place, so that in the upper or Tertiary bed of green-sand, deposited in the same place and under nearly the same conditions as the lower and Cretaceous two, *but we know not how many thousands of years after*, not a single one of all the species of Cretaceous mollusks, radiates, or marine vertebrates, mingled its remains with those of the new-comers.

II. New York in the Ice Period.—The excavation of New York Harbor and the trough of the Hudson seems to have been effected in late Tertiary times. During the first portion of the Tertiary age—the Eocene—the coast from New York southward was low, and the sea washed the base of the Alleghany Mountains, covering the coast-plain and depositing upon it the uppermost and most recent of the marl-beds of New Jersey. But in the middle and later Tertiary epochs—the Miocene and Pliocene—all the northern portion of the continent stood higher above the sea than now, for we find there no marine deposits of that age; and the immense numbers of fiords, or submerged valleys which fringe the coast, are, as Dana long since pointed out, the results of subaërial erosion and proofs of elevation. A genial climate then prevailed to the Arctic Sea, and all the continent was covered with a more luxuriant flora, and inhabited by a more varied fauna, than can now be found anywhere on its surface.

This was, indeed, for America, the golden age of animals and plants, and in all respects but one—the absence of man—the country was more interesting and picturesque than now. We must imagine, therefore, that the hills and valleys about the present site of New York were

covered with noble trees, and a dense undergrowth of species, for the most part different from those now living there; and that these were the homes and feeding-grounds of many kinds of quadrupeds and birds, which have long since become extinct. The broad plain which sloped gently seaward from the highlands must have been covered with a sub-tropical forest of giant trees and tangled vines teeming with animal life. This state of things doubtless continued through many thousands of years, but ultimately a change came over the fair face of Nature more complete and terrible than we have language to describe. From causes which are not yet fully understood, and into the discussion of which we cannot here enter, the climate of the northern hemisphere became gradually more severe, and that of Greenland, from being what it had been for ages, like that of our Southern States, became arctic as we now find it, and its luxuriant forests were replaced by fields of snow and ice. But the change did not stop here, for with increasing cold the ice-sheets spread southward and covered successively the mountains of Labrador, the Canadian highlands, and the hills of New England and New York. At the culmination of the Glacial period the ice reached as far south as Staten Island and Trenton, and all the country north of this line was buried under a great moving mass of ice, in places several thousand feet in thickness. At this time the present climate of Greenland had been transferred to New York; in the strongest possible contrast to that earlier time when the present climate of New York prevailed in Greenland. In the advent of the Ice period not only were all kinds of animals and plants exterminated or driven southward, and thus what had been a paradise was converted into a howling wilderness, but even the topography of the country was greatly modified. The ice-sheet moving from the north ground down or rounded over all projecting rock-masses, and filled up valleys with the *débris*, producing great abrasion in some places, and accumulations in others, until the whole face of the country was changed. In the vicinity of New York the ice moved from north-northwest to south-southeast, and was of such thickness that it crossed the trough of the Hudson diagonally, and probably, because this had been filled with transported material, was by it little deflected from its course. In other localities the old river-valleys were sometimes completely obliterated, and the drainage of the surface given new channels and even new direction. To this cause we may attribute the blocking up of the old line of drainage from the lake-basin through the Hudson, and its diversion to the present course of the St. Lawrence.

Now that the glaciers have left this region and have retreated again to the far north, we everywhere see evidence of the stupendous changes they wrought in the country over which they moved. North of the line which marks the margin of the glacier, we find the contour-lines rounded over and softened, ridges of granite converted into domes, and the hardest rocks grooved and striated, or ground smooth and even

polished. The whole surface of New York Island, where the rock is exposed, shows marks of glacial action, the upturned edges of gneiss being ground off to form a nearly plane surface, or, where ridges of more massive rock had existed, these are rounded over to form *roches moutonnées*. Fine examples of the latter may be seen in Central Park and on the east side of the island near Harlem.

The material which occupies so much of the troughs of the Hudson and East River is mostly glacial drift, clay, gravel, sand, and bowlders, scraped from the highlands by the great ice-sheet into these preglacial gorges. It is probable they were once filled to the brim, and that they were subsequently reëxcavated in part by the floods of water which resulted from the melting ice. After these ceased, and they were occupied by water standing at its present level, and moved only by tidal action, they were more or less silted up by the deposit of fine mud brought down by the larger and smaller streams, here checked in their

Fig. 8.

flow and losing their transporting power. The southern and lower portion of New York Island, which was under the lee of the higher, was covered with deposits left by the retreating glacier, and these were never afterward entirely removed. Here are now beds of sand and gravel which have in places been penetrated to the depth of one hundred feet or more. On the higher parts of the island and the adjacent country, the rock is generally bare or covered with soil, but even here depressions are filled with bowlders, clay, or gravel, often to the depth of several feet, and large transported bowlders are everywhere scattered over the surface. These latter have sometimes been derived from the rocks of the island, but most of them seem to have come from distant points, and always from the north and west. Rounded masses of trap are very common among the bowlders, and these have been brought across the Hudson, for there is no trap in place on the east side of the river. The trap-ledge which forms the summit of the Palisades is everywhere worn and scratched by glacial action, and the markings which it bears are generally concordant in direction with those of the rocks of New York Island and Westchester County, viz., about north-northwest and south-southeast. Even on the river-face of the hills which form the east bank of the Hudson, the bearing of the glacial scratches is essentially the same, showing that the movement of the great ice-sheet was little affected by any such trifling irregularity of the surface beneath it as the Hudson Valley.

We have no measure of the amount of erosion which New York Island and the adjacent country suffered during the Ice period, but it is not improbable that a mass a hundred feet in thickness was taken from the surface of all the region occupied by the ice.

Most of the finer material ground up by the glaciers was washed out to sea and deposited as the "Champlain clays." Of these there is very little showing in the vicinity of New York, since none of the coast from this point southward has been raised to display them; but a great continental elevation has since taken place toward the north, bringing them at Croton Point 100 feet, at Albany 250, at Burlington 400, at Montreal 500, at Labrador 800, at Davis Straits 1,000, and at Polaris Bay 1,800 feet above the present sea-level.

The coarser portion of the grist ground by the glacier remains as beds of gravel and sand, or heaps of bowlders scattered over the surface of the country where they were left as local moraines, or as the gravel-bars of streams flowing beneath the glacier. The greatest accumulation of material transported by the ice in all the country about New York is seen on Long Island, which is indeed a great terminal moraine heaped up along the margin of the continental glacier. As is generally known, Long Island is mostly composed of heaps of gravel and sand, which sometimes form hills from 200 to 300 feet in height, and in these no solid rock has been found in any exploration yet made. The formation of this huge gravel-bank seems to have been, in brief, as follows: The great ice-sheet, moving down from the north in Connecticut and Southern New York, passed over a region occupied mostly by hard, crystalline rocks. These were extensively worn away by it, and much of the material taken from the surface was pushed on as by a great scraper to its margin. When the ice-sheet reached the line of Long Island Sound, it passed from the area of upturned crystalline rocks on to the comparatively soft horizontal Tertiary and Cretaceous strata, which here formed a plain stretching seaward, from the highlands, just as they now do in New Jersey and more southern States. These were scooped out to form the basin of Long Island Sound, and the material excavated from it, as well as much brought from the country lying farther north, was banked up between this basin and the ocean. Thus it will be seen that, of the water-connections of New York Harbor, Long Island Sound is much the most modern; and yet, as a part of it occupies the site of the valley of a large stream—the Housatonic, with perhaps the Connecticut—which passed through the Hell Gate gorge, its formation must have been begun in preglacial times.

As has been said, the rock foundations of Long Island are almost entirely concealed, but a number of cases are reported of the penetration in wells of strata containing Cretaceous fossils, and there is little doubt that the Cretaceous series of New Jersey and Staten Island, represented by the Raritan sands, and the Amboy, Keyport, and Staten Island clays, once formed a continuous margin to the continent, all the way around

to Nantucket. These strata still probably underlie a large part of Long Island where they have been protected from erosion by the heavy beds of drift that cover them, while the shore-waves have eaten away all exposed portions. Evidence strongly confirmatory of the view that Cretaceous rocks have been scooped out of the basin of Long Island Sound is afforded by the fact that the drift of Long Island contains in immense numbers imperfectly-rounded blocks of a reddish-brown sandstone, filled with the impressions of dicotyledonous leaves—a rock nowhere yet found in place, but one which is probably the representative of the leaf-bearing Cretaceous sandstone of the Raritan River.

Whether the overlying Tertiary beds will be found on Long Island is perhaps doubtful, since they are not conterminous with the Cretaceous; but, from the fact that an outlier of this formation exists at Gay Head, Martha's Vineyard, it is highly probable that it was once continuous from Southern New Jersey.

On the preceding pages the history of the vicinity of New York has been traced backward for some millions of years. This history has been read from rock-graven records, which, although meagre and mutilated, give the generalities of the narrative with a truth and fidelity which shame all human history. It would be a pleasant duty to predict the future of this region, even in the same degree of fullness; but the future is as unknown to the geologist as to others. He learns, however, from his studies, that what we call *terra firma* is a type of instability, and that there is nothing stable but the law of change; and he can prophesy with confidence that in the distant future the history of the distant past will be, in part at least, repeated. Even now changes are in progress which, if they should continue a few thousand years, would very profoundly affect not only the aspects of this region, but its adaptability to human occupation. A number of facts indicate that the coast of New Jersey and Long Island is gradually sinking. From the marshes of New Jersey are taken the trunks of trees which could not have grown there except when it was drier ground, and on the shore stumps are seen, now under water, of trees which must have grown on land. So, too, the sea throws up in storms portions of turfy soil, once covered only by the air, and similar soil has been reached below the sea-level in pits dug through drifted sand along its margin. It is also said that the land boundaries have been changed and farms diminished even where the wash of the shore-waves produced no effect. The rate of this subsidence is very slow—only a few inches in a century—and it may at any time be arrested or reversed; but, should it continue, as it may, for some thousands of years, it would result in a submergence of land now valued at hundreds of millions of dollars, and a complete change of position in the seats of commerce and industry, which must always centre about this harbor. This possible catastrophe is, however, so uncertain and remote that it seems hardly sufficient to disturb the equanimity of at least this generation of inhabitants.

III. WHY NEW YORK IS THE COMMERCIAL METROPOLIS OF THE UNITED STATES.—The great commercial advantages of the site of the city of New York attracted the attention of the first voyagers who came to these shores. When Hendrick Hudson, passing through the Narrows, found within a commodious, landlocked harbor, and a broad and beautiful river, which floated his ships in safety more than a hundred miles into the interior of the continent, he clearly foresaw, and predicted, that this would be the great entrepot of foreign trade for the New World. The subsequent history of New York has fully demonstrated the advantages of its position, since a population of more than 2,000,000 has gathered immediately around its harbor, and it has become not only the business metropolis of a great nation, but the second in importance of the markets of the world. Those who have witnessed and shared the progress and prosperity of the city have been generally well satisfied to enjoy these, without any special inquiry into the causes which have produced them; and, indeed, it is not unlikely that they have accepted them as simply the fruit of their own intelligence and energy. It is doubtful, however, whether the merchants of New York have been more shrewd and enterprising than those of the other ports on our coast. It is not flattering to the vanity of men to assert that they are what their surroundings make them, but it is nevertheless in a great measure true, and New-Yorkers are probably no exception to the rule. The real secret of the unparalleled growth of New York lies in the peculiar topography of its vicinity.

The city is set on an island, of which the shore on every side is swept by tide-water. On the west it is bounded by the Hudson—river we call it, but really an arm of the sea—in which the ebb and flow of the tide are perceptible as far as Troy, one hundred and fifty miles from its mouth. On the east the island is encircled by tideways called Spuyten Duyvel Creek, Harlem River, and East River, the latter a deep channel which connects New York Harbor with Long Island Sound, and thus affords an important artery of internal commerce, and another outlet to the ocean. These two great natural canals, the Hudson and East Rivers, embracing the long and narrow island between them, unite in New York Harbor, one of the most beautiful and commodious in the world. Seen from the city, it seems to be completely landlocked, but communicates with the ocean through the Narrows, with Newark Bay through the Kill van Kull, and thence by Arthur's Kill with Raritan Bay.

Thus it will be seen that New York Harbor is the centre of a series of navigable tideways which add greatly to its adaptation to the wants of commerce, and constitute the most peculiar physical features in its surroundings. The little map given on the next page will show the connection of this system of water-ways more distinctly than any verbal description can.

To those who have not made topography a study, the interest and mystery of the origin of the navigable channels leading into New York

Harbor will not be apparent, and it may seem an easy explanation to assume that they have been formed by the ebb and flow of the tide which sweeps through them. The tides at New York, however, do not rise to a great height, and have very little eroding power. It should also be said that the channels are far too deep to have been cut by any agents now in operation. For instance, at Polhemus's Dock the depth of Hell

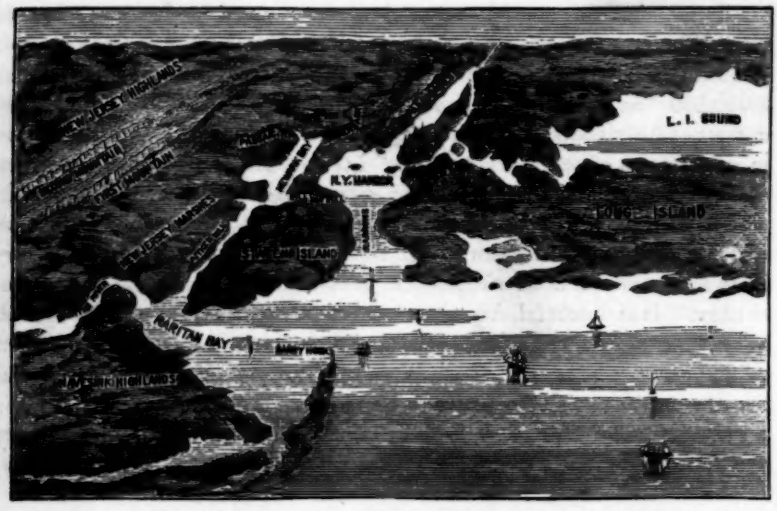

FIG. 4.—BIRD'S-EYE VIEW OF NEW YORK HARBOR AND ITS CONNECTIONS.

Gate channel is 170 feet, and there are many places in the East River where the depth is over 100 feet. The greatest depth of water in New York Harbor and the Hudson River is about sixty feet, but this does not represent the true depth of the channels, since they have been very much silted up, and their rock-bottoms are probably 200 or 300 feet below the water-surface. If they could be cleared of clay, sand, and gravel, they would be seen to be narrow gorges cut in solid rock as deep as that of Niagara, and resembling some of the cañons of the Western rivers. It is therefore certain that they could not have been produced by tidal action. There are only two ways in which such chasms could be formed: first, by earthquakes, opening fissures in the rocks; and, second, by the erosion of flowing streams. That they are not earthquake fractures is certain, since no such fissures are found in the country about in the line of these channels, and their rocky walls show no sign of disturbance, being similar on opposite sides, and doubtless continuous below. They have, in fact, been formed by draining streams when this part of the continent stood much higher than now above the ocean-level. The evidence of this is cumulative and conclusive. The facts which prove it are, briefly, as follows:

1. The trough of the Hudson has been shown, by the soundings of

the Coast Survey, to be distinctly marked upon the sea-bottom out to a point some eighty miles southeast of New York, and where the water is now over 500 feet deep. Here we reach the true margin of the continent, where the shore plunges rapidly down into the depths of the ocean; and here was for ages the mouth of the Hudson River; for the channel which leads to it could not possibly have been excavated except upon a land-surface.

2. Explorations made over a large part of the territory lying between the Atlantic and the Mississippi show that many of the draining streams are now flowing far above their ancient beds, and that these sometimes lie below the present ocean-level. For example, the Ohio flows in a valley the bottom of which is occupied by sand and gravel at least 100 feet thick. The rock-bottoms of the streams which empty into the Great Lakes are at their mouths sometimes 200 feet below the water-level. The Mohawk Valley is filled to a great depth with loose materials, the surface of which forms for long distances a nearly level plain, through which the present river meanders.

Innumerable instances of this kind could be cited, all of which go to prove that for ages the eastern half, at least, of this continent stood 500 to 600 feet higher above the ocean than now, and that during this time the draining streams with swiftly-flowing currents cut the surface into a network of deep channels not unlike the cañons of some of the rivers of the far West.

There seems to be good reasons for believing also that in this period of elevation the stream which drains the basin of the Great Lakes, called in different parts of its course the St. Mary's, the Detroit, the Niagara, and the St. Lawrence, flowed not through the modern channel, which passes the Thousand Islands and the Lachine Rapids, but, leaving the basin of Lake Ontario at its southeastern corner, traversed the now deeply-buried channel of the Mohawk, and entered the present valley of the Hudson somewhere near Albany—precisely where has not yet been determined, as heavy beds of drift cover and conceal its course for many miles in that vicinity. From Albany this ancient Hudson River flowed through a deeper and wilder valley than the present one, which is half filled with water, passed what is now New York Island, far below the present water-surface, was joined at the Battery by a large tributary from the east, issued from the highlands by a picturesque gate at the Narrows, and, traversing a littoral plain, emptied into the ocean eighty miles southeast from New York.

The limits of this article will not permit the presentation of all the facts which sustain this view, but a few of them will suffice to show that it hardly admits of doubt. These are briefly as follows:

An ancient connected line of drainage passes through the basin of the Great Lakes at least 200 feet below the present water-surface, deepening eastward, and reaching a level much below that of the bed of the St. Lawrence.

An old channel at least 200 feet deep connects Lake Huron and Lake Erie. Detroit is situated on the western side of it, and the rock lies there 130 feet below the surface.

Many of the streams now flowing into Lake Erie were once tributaries to the ancient river which traversed its valley and joined it far below the present water-level.

The old channel connecting Lake Erie and Lake Ontario apparently passed through Canada between Long Point and Hamilton. Heavy beds of drift, by which it is filled and concealed, here occupy the surface. The Niagara now flows over a rock-bed, for this is a comparatively modern river, which, following the line of lowest surface-levels, passed over a spur from the south shore of the lake-basin when the old channel was filled by glacial drift.

Some of the streams draining into the basin of Lake Ontario in former times cut their channels below the present ocean-level. All the salt-wells of Syracuse are sunk in one of these, which is filled with gravel and sand saturated with brine issuing from the Salina group that forms its walls. The rock-bottom of this old river-bed was reached in some of these wells at a depth of fifty feet below the present level of tide-water.

FIG. 5.—MAP SHOWING OLD DRAINAGE OF THE LAKE BASIN.

The valley of the Mohawk is a very deep channel of erosion, now half filled, which must have been traversed by a large stream flowing eastward at a level below that of the present ocean; and everything indicates that this was the ancient outlet of the basin of the Great Lakes.

The channel of the Hudson is apparently the only possible continu-

ation of this long line of drainage. As has been remarked, it is of great and yet unknown depth. The clay by which it is partially filled has been penetrated to a depth of about 100 feet along its margins. How deep it is in the middle portion can only be conjectured; but Hell Gate channel, which has been kept comparatively free by the force of the tides, is in places known to be nearly 200 feet deep; and, since this is a channel of erosion formed by a stream draining into the Hudson, the ancient bed of the Hudson must be still lower.

From the depth and distinctness of the old river-course on the submerged plain outside of the Narrows, we may reasonably infer that the old channel at New York is not much less than 300 feet deep.

We are compelled to conclude from these and other facts of similar import: 1. That the topographical features of the vicinity of New York were for the most part fashioned by the erosion of a system of watercourses which, in preglacial times, when the continent was higher than now, cut their valleys much deeper than would now be possible.

2. That there was here a group of hills composed of crystalline rocks, a sort of spur from the Alleghany belt, and that this range of hills was then seventy or eighty miles inland from the ocean, separated from it by a plain similar in its topographical relations to that which lies between the highlands of our Southern States and the present shore of the Atlantic.

3. At the period under consideration a river draining the basin of the Great Lakes, and in size the second on the continent, followed the course of the Mohawk and Hudson, and, passing through the New York hills, there left the highlands and flowed quietly on to the ocean.

4. Where New York Harbor now is, this great river received two important tributaries—one from the east through Hell Gate channel, which joined it at the Battery, the other from the west through the gorge of the Kill van Kull. Of these, the first is now represented by the Housatonic, then a larger stream, with a longer course and more tributaries; the second was formed by the Passaic and Hackensack, which united at the head of what is now Newark Bay, and emptied into the Hudson at the entrance to the Narrows. The junction of these two considerable branches so near each other seems to have produced the expansion of the valley which is now New York Harbor. This must then have been a very picturesque spot, as its outlet oceanward was a narrow pass bordered by the hills of Staten and Long Island, 500 feet in height. On the north, it was overlooked on one hand by the great wall of the Palisades, which rose 700 feet above the river; on the other, by a bold shoulder or headland, 400 feet in height, now New York Island, then a promontory, which separated the Housatonic and the Hudson to their junction at its southern extremity.

5. After the lapse of unnumbered ages, during which this nook among the hills was slowly prepared for the important part it was to play in the history of the yet unborn being—man—a quiet subsidence

of the land or elevation of the water began in this region. Gradually the sea flowed in over its shores, crept up the valleys of the streams, checking their flow and converting them into tideways, until it washed the base of the highlands. Up to this time the surface of the littoral plain in its gradual submergence formed a broad expanse of shallow

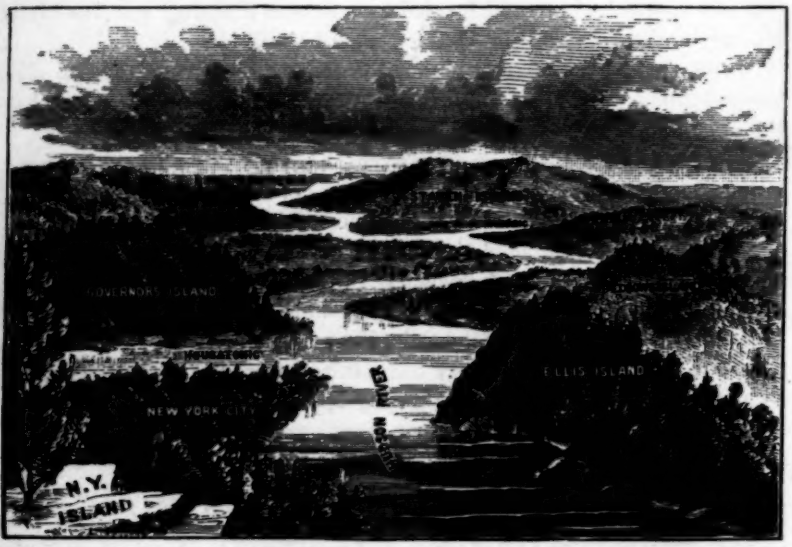

FIG. 6.—NEW YORK HARBOR IN PRE-GLACIAL TIMES, FROM SOUTH END OF NEW YORK ISLAND.

water bounded by a monotonous line of beach, with no good harbors—a shifting, dangerous shore, such as is most dreaded by mariners. By further subsidence, however, the water flowed up into the valleys among the New York hills and into the deeper river-channels, making of the first safe, landlocked harbors, of the second navigable inlets or tideways. In this manner were produced the magnificent harbor and the system of natural canals connected with it, which determined the position and created the subsequent prosperity of the commercial emporium of the New World.

The subsidence which resulted in the formation of New York Harbor and its connections seems also to have affected all the coast, and the influx of the sea-water filled the valleys of the rivers which drained the Atlantic slope south of New York, and gave it the fringed and irregular outline which constitutes its most striking characteristic. James River, York River, the Potomac, the Susquehanna, and the Delaware, are, like the Hudson, half-drowned rivers—if we may use the expression—for all the lower portions of their valleys are estuaries, in which the tide sets up to the base of the highlands. But that portion of the littoral plain which separates these estuaries is too low, too much cut up with water-ways, and its harbors are too shallow and ill-

defined, to afford proper sites for great shipping-ports. Hence the cities of this region—Richmond, Washington, Baltimore, and Philadelphia—are situated at the head of navigation, where the rivers come down from the highlands on to the plain; and they are located like Albany, remote from the seaboard, with which they are connected by long and somewhat tortuous channels of inland navigation. New York, on the contrary, is located directly on the coast, because here alone the highlands reach to the sea, and their submerged valleys and river-channels form commodious, rock-girt harbors, immediately accessible from the ocean. It will be seen at a glance that this fact gives it great commercial advantages, and has been the most potent influence in making this the chief port of entry for the country.

FIG. 7.—MAP SHOWING OLD CHANNEL AND MOUTH OF THE HUDSON.

On the Southern coast there is no harbor at all comparable with that of New York except Norfolk. This is deep, roomy, and accessible to the sea—advantages which are destined to give it permanent and increasing importance. But it is less central to the population and business of the country; and, while its inland water connections through Chesapeake Bay and the tidal rivers which open into it are more extensive than those which the harbor of New York possesses, they are less favorably situated in their relations to the present and future internal commerce of the country.

The great advantage which New York enjoys for trade with the interior consists in its accessibility from the basin of the Great Lakes where the most rapid accumulation of population and wealth of the last half-century has taken place, and where the business of the country is destined to concentrate in the future. As has been stated in the preceding pages, the drainage of the lake-basin apparently flowed for

ages by New York; and it is an interesting fact that the great tide of population and business which has set in from the Eastern States toward the interior has chiefly passed through the gap cut in the highlands by the old river whose course we have endeavored to trace. The topographical features of this pass led to the construction of the Erie Canal, and it was comparatively easy to reëstablish there the old line of water communication. In later years the same influences caused the construction through it of the most important railroad line of the world. The natural advantages of this route are such as to give New York and her connections with the interior a positive and inalienable superiority over all competing ports and lines of traffic—a superiority which, though it may be temporarily abrogated by municipal misgovernment, or be diverted from public to private profit by individual or corporate rapacity, will ultimately and always assert itself, and give to this city a continuance of the prosperity that has attended her past career.

EDUCATION AS A SCIENCE.

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V.—THE EMOTIONS IN EDUCATION.

The Emotion of Power.—The state named the feeling or emotion of power expresses a first-class motive of the human mind. It is, however, shown, with great probability, not to be an independent source of emotion. It very often consists of a direct reference to possessions or worldly abundance. In other cases, I cannot doubt that the pleasure of malevolent infliction is an element; the love of domineering, or subjecting other people's wills, would be much less attractive than it is if malevolent possibilities were wholly left out.

Power in the actual is given by bodily and mental superiority, by wealth, and by offices of command. Hence it can be enjoyed in any high degree only by a few. It is, however, capable of great ideal expansion; we can derive gratification from the contemplation of superior power, and the outlets for this are numerous, including not merely the operations of living beings, but the forces of inanimate Nature. For example, the sublime is an ideal of great might or power.

We have now almost, but not quite, led up to the much-urged educational motive, the gratification of the sense of self-activity in the pupils. This must afterward undergo a very searching examination. Let us, however, first briefly review another leading class of well-marked feelings, those designated by the familiar terms, self-complacency, pride, vanity, love of applause. Whether these be simple or

compound in their nature, they represent feelings of great intensity, and they are specially invoked in the sphere of education.

THE EMOTIONS OF SELF.—"Self" is a very wide word. "Selfish," "self-seeking," "self-love," might be employed without bringing any new emotions to the front. All the sources of pleasure, and all the exemptions from pain, that have been or might be enumerated under the senses and the emotions, being totalized, could be designated as "self" or "self-interest." But, connected with the terms self-esteem, self-complacency, pride, vanity, love of praise, there are new varieties of feeling, albeit they are but offshoots from some of those already given. It is not our business to trace the precise derivation of these complex modes, except to aid in estimating their value as a distinct class of motives.

There is an undoubted pleasure in finding in ourselves some of those qualities that, seen in other men, call forth our love, admiration, reverence, or esteem. The names self-complacency, self-gratulation, self-esteem, indicate emotions of no little force. They have a good influence in promoting the attainment of excellence; their defect is ascribable to our enormous self-partiality: for which cause they are usually concealed from the jealous gaze of our fellows. It is only on very special occasions that persuasion is made to operate through these powerful feelings; they are too ready to turn round and make demands that cannot be complied with.

A still higher form of self-reflected sentiment is that designated by the love of praise and admiration. We necessarily feel an enhanced delight when our own good opinion of self is echoed and sustained by the expressions of others. This is one of the most stirring influences that man can exert over man. It exists in many gradations, according to our love, regard, or admiration, for the persons bestowing it, as well as our dependence upon them, and according to the number joining in the tribute.

The bestowal of praise is an act of justice to real merit, and should take place apart from ulterior considerations. But in rewarding, as in punishing, we cannot help looking beyond the present; we have in our eye merits that are yet to be achieved. The fame that attends intellectual eminence is an incentive to study, and the educator has this great instrument at his command.

Praise, to be effectual and safe, has to be carefully apportioned, so as to approve itself to all concerned. As the act of praising does not terminate with the moment, but establishes claims for the future, thoughtless profusion of compliment defeats itself. Praise may operate in the form of warm, kindly expression, and no more; in which sense it is an offering of affection, and has a value in that character alone. A pleased smile is a moral influence.

Discipline, properly so called, works in the direction of pain; pleasures are viewed in their painful obverse. The positive value of delights

is of consequence as the starting-point wherefrom to count the efficacy of deprivations. The pains opposed to the pleasures of self-esteem and praise are among the most powerful weapons in the armory of the disciplinarian. They are the chief reliance of such as deprecate corporeal inflictions. Bentham's elaborate scheme of discipline in the "Chrestomathia" is a manipulation of the motives of praise and dispraise, which he would fain make us believe to be all-sufficient.

Of the two divisions of the present class of emotions, namely, self-esteem on the one hand, and desire of praise on the other, the opposite of the first—self-reproach, self-humbling—is very little under foreign influence. To induce people to think meanly of themselves is no easy task; with the mass of human beings it is wellnigh hopeless. Any success that attends the endeavor is an offshoot from the second member of the class under discussion, namely, dispraise, depreciation. There is no mistaking our aim here; we can make our power felt in this form, whether it has the other effect or not. People live so much on one another's good opinion that the remission tells in an instant; from the simple abatement or loss of estimation there is a descent into the depths of disesteem with a result of unspeakable suffering. The efforts that the victim makes to right himself under censure only show how keenly it is felt. There can be little doubt that on the delicate handling of this instrument must depend the highest refinements of moral control.

THE EMOTIONS OF INTELLECT.—The pleasurable emotions incident to the exercise of the intellectual powers have not the formidable magnitude that we have assigned to the foregoing groups. Indeed, on the occasions when they seem to burst forth with an intense glow, we can discern the presence of emanations from these other great fountains of feeling.

It is an effort of prime importance to trace exhaustively the inducements and allurements to intellectual exertion. What are the intrinsic charms of knowledge, whether in pursuit or in possession? The difficulty of the answer is increased rather than diminished by the flow of fifty years' rhetoric.

Knowledge has such a wide compass, embraces such various ingredients, that, until we discriminate the kinds of it, we cannot speak precisely either of its charms or of its absence of charm. Some sorts of knowledge are interesting to everybody; some interest only a few. The serious part of the case is, that the most valuable kinds of knowledge are often the least interesting.

The important distinction to be drawn here is between individual or concrete knowledge and general or abstract knowledge. As a rule, particulars are interesting as well as easy; generals uninteresting and hard. When particulars are not interesting, it is often from their being overshadowed by generals. When generals are made interesting, it is by a happy reflected influence upon the particulars. It would serve

nearly all the purposes of the teacher to know the best means of overcoming the repugnance and the abstruseness of general knowledge.

Waiving for a time the niceties of the abstract idea, and the obstacles in the way of its being readily comprehended, we may here adduce certain motives that coöperate with the teacher's endeavors to impress it. A little attention, however, must first be given to the various kinds of interest that attach to individual or particular facts.

Any kind of knowledge, whether particular or more or less general, that is obviously involved in any of the strong feelings or emotions that we have passed in review, is by that very fact interesting. Now, a great many kinds of knowledge are implicated with those various feelings. To avoid pains, and obtain pleasures, it is often necessary to know certain things, and we willingly apply our minds to learn those things; and the more so, the more evident their bearing upon the gratification of our desires. A vast quantity of information respecting the world, and respecting human beings, is gained in this way; and it constitutes an important basis of even the highest acquisitions.

The readiness to imbibe this immediately fructifying knowledge is qualified by its being difficult or abstruse; we often prefer ignorance, even in matters of consequence, to intellectual labor.

All the natural objects that bear upon our subsistence, our wants, our pleasures, our exemptions from pain, are individually interesting to us, and become known in respect of their special efficacy. Our food, and all the means of procuring it, our clothing and shelter, our means of protection, our sense-stimulants, are studied with avidity, and remembered with ease. This department of knowledge, notwithstanding its vital concern, is apt to be considered as groveling; it has, however, the recommendation of truth. We do not encourage ourselves in any deceptions in such matters; and, if we make mistakes, it is owing to the obscurity of the case, rather than to our indifference, or to any motive for perverting the facts. Indeed, this is the department that first supplied to mankind the best criterion of certainty.

There is a different class of objects that appeal, not to the more pressing utilities of subsistence, safety, and comfort, but to the gratifications of the higher senses and the emotions: the pleasures of touch, sight, and hearing; the social and anti-social emotions. These comprise all the more striking objects of the world: the sun and celestial sphere, the earth's gay coloring and sublime vastness; the innumerable objects, inanimate and animate, that tickle some sense or emotion. In proportion as human beings are set free from the struggle for subsistence do they lay themselves open to the seinfluences, and so enlarge the sphere of natural knowledge. Individual things become interesting and known from inspiring these feelings. The culminating interest, however, is in living beings, and especially persons of our own species. The intellectual impressions thus left upon us are lively, but not necessarily correct as to the facts.

However all this may be, it is to individual things that we must refer the first beginnings of knowledge, the interest and the facility of acquisition. There are great inequalities in this interest and consequent facility; many individual objects inspire no interest at all in the first instance; while some of these become interesting afterward, in consequence of our discovering in them relationships to things of interest.

One notable distinction among the objects of knowledge is the distinction between movement or change, and stillness or inaction. It is movement that excites us most; still-life is rendered interesting by reference to movement. We are aroused and engrossed by all moving things; our attention is turned away from objects at rest to contemplate movements; and we imbibe with great rapidity the impressions of moving objects.

This brief survey of the sphere of individuality and of the various attractions presented by individuals is preparatory to the consideration of the most arduous part of knowledge—the knowledge of generals or generality. All the difficulties of the higher knowledge have reference to the generalizing process—the seeing of one in many. The arts of the teacher and the expositor are supremely requisite in sweetening the toil of this operation. At the present stage, however, the question is to assign the motives connected with general knowledge as distinct from individual knowledge.

General knowledge, represented by science, consists in holding together, by a single grasp, whole classes of objects, of facts, of operations. This must, by the very nature of the case, be more severe than holding an individual. To form an idea of one tree that we have repeatedly surveyed at leisure, round and round, is about the easiest exertion whether of attention or of memory. To form an idea of ten trees partly agreeing and partly differing among themselves is manifestly an entirely altered task; it is to exchange comparative simplicity for arduous complexity; yet this is what is needed everywhere in the higher knowledge.

The first emotional effect attendant on the process of generalizing facts, and serving to lighten the intellectual burden, is the flash of identity in diversity, an exhilarating charm that has been felt in every age by the searchers after truth. Many of the grandest discoveries in science have consisted, not in bringing to light any new individual fact, but in seeing a likeness between things formerly regarded as wholly unlike. Such was the great discovery of gravitation. The first flash of the recognition of a common power in the motions of the planets and the flight of a projectile on the earth was unutterably splendid; and, after a hundred repetitions, the emotional charm is unexhausted.

With the emotion of exhilarating surprise at the discovery of likeness among things seemingly unlike, there is another grateful feeling, the relief from an intellectual burden. This appears at first sight a

contradiction to what has been already said respecting the greater laboriousness of general knowledge: but the contrariety is only apparent. To contract an impression of one single individual, after plenty of time given to attend to it, is the easiest supposable mental effort. But such is the multiplicity of things, that we must learn to know and remember vast numbers of individuals; and we soon feel ourselves overpowered by the never-ending demands upon us. We must know many persons, many places, many houses, many natural objects; and our capability of memory is in danger of exhaustion before we have done. Now comes in, however, the discovery of identities, whereby the work is shortened. If a new individual is exactly the same as the old, we are saved the labor of a new impression; if there is a slight difference, we have to learn that difference and no more. In actual experience, the case is that there are numerous agreements in the world, but accompanied with differences; and, while we have the benefit of the agreements, we must take notice of the differences. What makes a general notion difficult is that it represents a large number of objects that, while agreeing in some respects, differ in others. This difficulty is the price that we pay for an enormous saving in intellectual labor.

The overcoming of isolation in the multitude of particulars, by flashes of identity, is the progress of our knowledge in one direction; it is the satisfaction that we express when we say we understand or can account for a thing. Lightning was accounted for when it was identified with the electric spark: besides the exhilarating surprise at the sameness of two facts in their nature so different and remote, men had the further satisfaction of saying that they learned what lightning is. Thus by discoveries of identity we are enabled to explain the world, to assign the causes of things, to dissipate in part the mysteriousness that everywhere surrounds us.

When a discovery of identification is made among particulars hitherto looked upon as diverse, the interest created is all-sufficient to secure our appreciation. This is the alluring side of generalities. The repugnant aspect of them is seen in the technicalities that are invented to hold and express them—general or abstract designations, diagrams, and formulas. When it is proposed to indoctrinate the mind in these things, by themselves, and at a stage when the condensing and explaining power of the identities is as yet unawakened, the whole machinery seems an uncouth jargon. Hence the attempt to afford relief to the faculties by teaching the dry symbols of arithmetic and geometry, through the aid of examples in the concrete, and in all the abstract sciences to afford plenty of particulars to illustrate the generalities. This is good so far; but the real interest that overcomes the dryness arises only when we can apply the generalities in tracing identities, in solving difficulties, and in shortening labor; an effect that comes soonest to those that have already some familiarity with the field where the formulas are applicable. The liking for algebra and for geometry pro-

ceeds apace when one sees the marvels of curious problems solved, unlikely properties discovered, among numbers and geometrical figures. A certain ease in holding in the memory the abstract symbols, after a moderate application, is enough to prepare us for a positive relish in the pursuit. Such is the case with generalities in all departments. If we can hold on till they bear their fruits in the explanation of things that we have already begun to take notice of, the pursuit is sustained by a genuine and proper scientific interest, whose real groundwork, however deeply hidden, is the stimulus of agreement among differing particulars, and the lightening of the intellectual labor in comprehending the world. These are the feelings that have to be awakened in the minds of pupils when groaning under the burden of abstractions.

The opposition of the concrete and the abstract, while but another way of expressing the opposition of the particular and the general, brings into greater prominence the highly *composite* or combined character of individuality. The individual thing is usually a compound of many qualities, each of which has to be abstracted in turn, in rising to general notions; any individual ball has, in addition to its round form, the properties called weight, hardness, color, and so on. Now, this composite nature, by charming several senses at once, gives a greater interest to individuals, and urges us to resist that process of decomposition, and separate attention, to which are given the designations "abstraction" and "analysis." It is for individuals in all their multiplicity of influence that we contract likings or affections; and, according as the charm of sense, and especially the color-sense, is strong in us, we are averse to the classing or generalizing operation. A fire is an object of strong individual interest: to rise from this to the general notion of the oxidation of carbon under all varieties of mode, including cases with no intrinsic charm, is to quit with reluctance an agreeable contemplation. The emotions now described—the pleasure of identity, and the lightening of labor—are of avail to counterwork this reluctance.

The second of the two motives that we have coupled together—the easing of intellectual labor—may be viewed in another light. When objects are viewed as operating agents in the economy of the world, as causes or instruments of change, they work by their qualities or powers in separation, and not by their entire individuality or concreteness. An iron bar, or a poker, is an individual concrete thing; but, when we come to use it, we put in action its various qualities separately. We may employ it as a weight, in which case its other properties are of no account; we use it as a lever, and bring into play simply its length and its tenacity. We can put it in motion as a moving power, wherein its inertia is alone taken into account, with perhaps its form. In all these instances, the magnetical and the chemical and the medicinal properties of iron are unthought of. Now, this consideration opens up an important aid to the abstracting process, the analytic separation of properties, as opposed to the mind's fondness for clinging to concrete individuality.

When we are working out practical ends, we must follow Nature's method of working; and, as that is by isolating the separate qualities, we must perform the act of mental isolation, which is to abstract, or consider, one power to the neglect of the rest. When we want to put forth heavy pressure, we think of various bodies solely as they can exert weight, in however many other ways they may invite or charm our sense. This is to generalize or to form a general notion of weight; and the motive to conceive it is practical need or necessity.

This motive of practical need at once brings us to the very core of causation, viewed as a merely speculative notion. The cause of anything is the agent that would bring that thing into being, suppose we were in want of it. The cause of warmth in a room is combustion properly arranged: we use this fact for practical purposes; and we may also use it for satisfying mere curiosity. We enter a warm room; we may desire to know how it has been made warm, and we are satisfied by being told that there has been, or is now somewhere, a fire in communication with it.

Thus it is that in proportion as we come to operate upon the world practically ourselves, and from that proceed to contemplate causation at large, we are driven upon the abstracting and analyzing process, so repugnant to one large portion of our feelings. Science finds an opening in our minds at this point, when otherwise we might need the proverbial surgical operation.

These observations will serve to illustrate the working of the emotion named Curiosity, which is justly held to be a great power in teaching. Curiosity expresses the emotions of knowledge viewed as desire; and more especially the desire to surmount an intellectual difficulty once felt. Genuine curiosity belongs to the stage of advanced and correct views of the world.

Much of the curiosity of children, and of others besides children, is a sham article. Frequently it is a mere display of egotism, the delight in giving trouble, in being pandered to and served. Questions are put, not from the desire of rational information, but for the love of excitement. Occasionally the inquisitiveness of a child provides an opportunity for imparting a piece of real information; but far oftener not. By ingeniously circumventing a scientific fact, one not too high for a child's comprehension, we may awaken curiosity and succeed in impressing the fact. Try a child to lift a heavy weight first by the direct pull, and then by a lever or a set of pulleys, and probably you will excite some surprise and wonder, with a desire to know something further about the instrumentality. But one fatal defect of the childish mind is the ascendency of the personal or anthropomorphic conception of cause. This, no doubt, is favorable to the theological explanation of the world, but wholly unsuited to physical science. A child, if it had any curiosity at all, would like to know what makes the grass

grow, the rain fall, the wind howl, and generally all things that are occasional and exceptional; an indifference being contracted toward what is familiar, constant, and regular. When anything goes wrong, the child has the wish to set it right, and is anxious to know what will answer the purpose; this is the inlet of practice, and, by this, correct knowledge may find its way to the mind, provided the power of comprehension is sufficiently matured. Still the radical obstacle remains—the impossibility of approaching science at random, or taking it in any order; we must begin at the proper beginning, and we may not always contrive to tickle the curiosity at the exact stage of the pupil's understanding. Every teacher knows, or should know, the little arts of giving a touch of wonder and mystery to a fact before the explanation is given; all which is found to tell in the regular march of exposition, but would be lost labor in any other course.

The very young, those that we are working upon by gentle allurement, are not properly competent to learn the "how" or "wherefore" of any important natural fact; they cannot even be made to desire the thing in the proper way. They are open chiefly to the charm of sense novelty and variety, which, together with accidental charm or liking, impresses the pictorial or concrete aspects of the world, whether quiescent or changing, the last being the most powerful. They further are capable of understanding the more palpable conditions of many changes without penetrating to ultimate causes. They learn that to light a fire there must be fuel and a light applied; that the growth of vegetables needs planting or sowing, together with rain and sunshine through a summer season. The empirical knowledge of the world that preceded science is still the knowledge that the child passes through in the way to science; and all this may be guided so as to prepare for the future scientific revelations. In other respects the so-called curiosity of children is chiefly valuable as yielding ludicrous situations for our comic literature.

THE PROGRESS OF ANTHROPOLOGY.[1]

By Professor T. H. HUXLEY.

WHEN I undertook, with the greatest possible pleasure, to act as a lieutenant of my friend the president of this section, I steadfastly purposed to confine myself to the modest and useful duties of that position. For reasons, with which it is not worth while to trouble you, I did not propose to follow the custom which has grown up in the Association of delivering an address upon the occasion of taking the

[1] Address before the Department of Anthropology of the British Association at its recent meeting held in Dublin, August 14, 1878.

chair of a section or department. In clear memory of the admirable addresses which you have had the privilege of hearing from Prof. Flower, and just now from Dr. McDonnell, I cannot doubt that that practice is a very good one; but I would venture to say, to use a term of philosophy, that it looks very much better from an objective than from a subjective point of view. But I found that my resolution, like a great many good resolutions that I have made in the course of my life, came to very little, and that it was thought desirable that I should address you in some way. But I must beg of you to understand that this is no formal address. I have simply announced it as a few introductory remarks, and I must ask you to forgive whatever of crudity and imperfection there may be in the mode of expression of what I have to say, although naturally I shall do my best to take care that there is neither crudity nor inaccuracy in the substance of it. It has occurred to me that I might address myself to a point in connection with the business of this department which forces itself more or less upon the attention of everybody, and which, unless the bellicose instincts of human nature are less marked on this side of St. George's Channel than on the other, may possibly have something to do with the large audiences we are always accustomed to see in the anthropological department. In the Geological Section I have no doubt it will be pointed out to you, or, at any rate, such knowledge may crop up incidentally, that there are on the earth's surface what are called *loci* of disturbance, where, for long ages, cataclysms and outbursts of lava and the like take place. Then everything subsides into quietude; but a similar disturbance is set up elsewhere. In Antrim, at the middle of the Tertiary epoch, there was such a great centre of physical disturbance. We all know that at the present time the earth's crust, at any rate, is quiet in Antrim, while the great centres of local disturbance are in Sicily, in Southern Italy, in the Andes, and elsewhere. My experience of the British Association does not extend quite over a geological epoch, but it does go back rather longer than I care to think about; and, when I first knew the British Association, the *locus* of disturbance in it was the Geological Section. All sorts of terrible things about the antiquity of the earth, and I know not what else, were being said there, which gave rise to terrible apprehensions. The whole world, it was thought, was coming to an end, just as I have no doubt that, if there were any human inhabitants of Antrim in the middle of the Tertiary epoch, when those great lava-streams burst out, they would not have had the smallest question that the whole universe was going to pieces. Well, the universe has not gone to pieces. Antrim is, geologically speaking, a very quiet place now, as well cultivated a place as one need see, and yielding abundance of excellent produce; and so, if we turn to the Geological Section, nothing can be milder than the proceedings of that admirable body. All the difficulties that they seemed to have encountered at first have died away, and statements that were the hor-

rible paradoxes of that generation are now the commonplaces of schoolboys. At present the *locus* of disturbance is to be found in the Biological Section, and more particularly in the anthropological department of that section. History repeats itself, and precisely the same terrible apprehensions which were expressed by the aborigines of the Geological Section, in long far-back time, is at present expressed by those who attend our deliberations. The world is coming to an end, the basis of morality is being shaken, and I don't know what is not to happen, if certain conclusions which appear probable are to be verified. Well, now, whoever may be here thirty years hence—I certainly cannot—but, depend upon it, whoever may be speaking at the meeting of this department of the British Association thirty years hence will find, exactly as the members of the Geological Section have found, on looking back thirty years, that the very paradoxes and conclusions, and other horrible things that are now thought to be going to shake the foundations of the world, will by that time have become parts of everyday knowledge and will be taught in our schools as accepted truth, and nobody will be one whit the worse.

The considerations which I think it desirable to put before you, in order to show the foundations of the conclusions at which I have very confidently arrived, are of two kinds. The first is a reason based entirely upon philosophical considerations, namely, this: that the region of pure physical science, and the region of those questions which specially interest ordinary humanity, are apart, and that the conclusions reached in the one have no direct effect in the other. If you acquaint yourself with the history of philosophy, and with the endless variations of human opinion therein recorded, you will find that there is not a single one of those speculative difficulties which at the present time torment many minds as being the direct product of scientific thought which is not as old as the times of Greek philosophy, and which did not then exist as strongly and as clearly as they do now, though they arose out of arguments based upon merely philosophical ideas. Whoever admits these two things—as everybody who looks about him must do—whoever takes into account the existence of evil in this world and the law of causation—has before him all the difficulties that can be raised by any form of scientific speculation. And these two difficulties have been occupying the minds of men ever since man began to think. The other consideration I have to put before you is that, whatever may be the results at which physical science as applied to man shall arrive, those results are inevitable—I mean that they arise out of the necessary progress of scientific thought as applied to man. You all, I hope, had the opportunity of hearing the excellent address which was given by our president yesterday, in which he traced out the marvelous progress of our knowledge of the higher animals which has been effected since the time of Linnæus. It is no exaggeration to say that at this present time the merest tyro knows a thousand times as

much on the subject as is contained in the work of Linnæus, which was then the standard authority. Now, how has that been brought about? If you consider what zoölogy, or the study of animals, signifies, you will see that it means an endeavor to ascertain all that can be studied, all the answers that can be given respecting any animal under four possible points of view. The first of these embraces considerations of structure. An animal has a certain structure, a certain mode of development, which means a series of stages in that structure. In the second place, every animal exhibits a great number of active powers, the knowledge of which constitutes its physiology; and under those active powers we have, as physiologists, not only to include such matters as have been referred to by Dr. McDonnell in his observations, but to take into account other kinds of activity. I see it announced that the Zoölogical Section of to-day is to have a highly-interesting paper by Sir John Lubbock on the habits of ants. Ants have a polity, and exhibit a certain amount of intelligence, and all these matters are proper subjects for the study of the zoölogist as far as he deals with the ant.

There is yet a third point of view in which you may regard every animal. It has a distribution. Not only is it to be found somewhere on the earth's surface, but paleontology tells us, if we go back in time, that the great majority of animals have had a past history—that they occurred in epochs of the world's history far removed from the present. And, when we have acquired all that knowledge which we may enumerate under the heads of anatomy, physiology, and distribution, there remains still the problem of problems to the zoölogist, which is the study of the causes of those phenomena, in order that we may know how those things came about. All these different forms of knowledge and inquiry are legitimate subjects for science, there being no subject which is an illegitimate subject for scientific inquiry, except such as involves a contradiction in terms, or is itself absurd. Indeed, I don't know that I ought to go quite so far as this at present, for, undoubtedly, there are many benighted persons who have been in the habit of calling by no less hard names conceptions which our president tells us must be regarded with much respect. If we have four dimensions of space we may have forty dimensions, and that would be a long way beyond that which is conceivable by ordinary powers of imagination. I should, therefore, not like to draw too closely the limits as to what may be contradiction to the best-established principles. Now, let us turn to a proposition which no one can possibly deny—namely, that there is a distinct sense in which man is an animal. There is not the smallest doubt of that proposition. If anybody entertains a misgiving on that point, he has simply to walk through the museum close by in order to see that man has a structure and a framework which may be compared, point for point and bone for bone, with those of the lower animals. There is not the smallest doubt, moreover, that, as to the manner of his becoming, man is developed, step by step, in exactly the same way as they are. There

is not the smallest doubt that his activities—not only his mere bodily functions, but his other functions—are just as much the subjects of scientific study as are those of ants or bees. What we call the phenomena of intelligence, for example (as to what else there may be in them, the anthropologist makes no assertion), are phenomena following a definite causal order just as capable of scientific examination, and of being reduced to definite law, as are all those phenomena which we call physical. And just as ants form a polity and a social state, and just as these are the proper and legitimate study of the zoölogist, so far as he deals with ants, so do men organize themselves into a social state; and, though the province of politics is of course outside that of anthropology, yet the consideration of man, so far as his instincts lead him to construct a social economy, is a legitimate and proper part of anthropology, precisely in the same way as the study of the social state of ants is a legitimate object of zoölogy. So with regard to other and more subtile phenomena. It has often been disputed whether in animals there is any trace of the religious sentiment. That is a legitimate subject of dispute and of inquiry; and, if it were possible for my friend Sir John Lubbock to point out to you that ants manifest such sentiments, he would have made a very great and interesting discovery, and no one could doubt that the ascertainment of such a fact was completely within the province of zoölogy. Anthropology has nothing to do with the truth or falsehood of religion—it holds itself absolutely and entirely aloof from such questions—but the natural history of religion, and the origin and the growth of the religions entertained by the different kinds of the human race, are within its proper and legitimate province.

I now go a step further, and pass to the distribution of man. Here, of course, the anthropologist is in his special region. He endeavors to ascertain how various modifications of the human stock are arranged upon the earth's surface. He looks back to the past, and inquires how far the remains of man can be traced. It is just as legitimate to ascertain how far the human race goes back in time as it is to ascertain how far the horse goes back in time; the kind of evidence that is good in the one case is good in the other; and the conclusions that are forced on us in the one case are forced on us in the other also. Finally, we come to the question of the causes of all these phenomena, which, if permissible in the case of other animals, is permissible in the animal man. Whatever evidence, whatever chain of reasoning justifies us in concluding that the horse, for example, has come into existence in a certain fashion in time, the same evidence and the same canons of logic justify us to precisely the same extent in drawing the same kind of conclusions with regard to man. And it is the business of the anthropologist to be as severe in his criticism of those matters in respect to the origin of man as it is the business of the paleontologist to be strict in regard to the origin of the horse; but for the scientific man there is

neither more nor less reason for dealing critically with the one case than with the other. Whatever evidence is satisfactory in one case is satisfactory in the other; and if any one should travel outside the lines of scientific evidence, and endeavor either to support or oppose conclusions which are based upon distinctly scientific truths, by considerations which are not in any way based upon scientific logic or scientific truth—whether that mode of advocacy was in favor of a given position, or whether it was against it—I, occupying the chair of the section, should, most undoubtedly, feel myself called upon to call him to order, and to tell him that he was introducing considerations with which we had no concern whatever.

I have occupied your attention for a considerable time; yet there is still one other point respecting which I should like to say a few words, because some very striking reflections arose out of it. The British Association met in Dublin twenty-one years ago, and I have taken the pains to look up what was done in regard to our subject at that period. At that time there was no anthropological department. That study had not yet differentiated itself from zoölogy, or anatomy, or physiology, so as to claim for itself a distinct place. Moreover, without reverting needlessly to the remarks which I placed before you some time ago, it was a very volcanic subject, and people rather liked to leave it alone. It was not until a long time subsequently that the present organization of this section of the Association was brought about; but it is a curious fact that, although proper anthropological subjects were at the time brought before the Geographical Section—with the proper subject of which they had nothing whatever to do—I find that even then more than half of the papers that were brought before that section were, more or less distinctly, of an anthropological cast. It is very curious to observe what that cast was. We had systems of language—we had descriptions of savage races—we had the great question, as it then was thought, of the unity or multiplicity of the human species. These were just touched upon, but there was not an allusion in the whole of the proceedings of the Association at that time to those questions which are now to be regarded as the burning questions of anthropology. The whole tendency in the present direction was given by the publication of a single book, and that not a very large one—namely, "The Origin of Species." It was only subsequent to the publication of the ideas contained in that book that one of the most powerful instruments for the advance of anthropological knowledge—namely, the Anthropological Society of Paris—was founded. Afterward the Anthropological Institute of this country and the great Anthropological Society of Berlin came into existence, until it may be said that now there is not a branch of science which is represented by a larger or more active body of workers than the science of anthropology. But the whole of these workers are engaged, more or less intentionally, in providing the data for attacking the ultimate great problem,

whether the ideas which Darwin has put forward in regard to the animal world are capable of being applied in the same sense and to the same extent to man. That question, I need not say, is not answered.

It is a vast and difficult question, and one for which a complete answer may possibly be looked for in the next century; but the method of inquiry is understood; and the mode in which the materials are now being accumulated bearing on that inquiry, the processes by which results are now obtained, and the observation of these phenomena, lead to the belief that the problem also, some day or other, will be solved. In what sense I cannot tell you. I have my own notion about it, but the question for the future is the attainment, by scientific processes and methods, of the solution of that question. If you ask me what has been done within the last twenty-one years toward this object, or rather toward clearing the ground in the direction of obtaining a solution, I don't know that I could lay my hand upon much of a very definite character — except as to methods of investigation — save in regard to one point. I have some reason to know that about the year 1860, at any rate, there was nothing more volcanic, more shocking, more subversive of everything right and proper, than to put forward the proposition that, as far as physical organization is concerned, there is less difference between man and the highest apes than there is between the highest apes and the lowest. Now, my memory carries me back sufficiently to remind me that, in 1860, that question was not a pleasant one to touch on.

The other day I was reading a recently-published valuable and interesting work, "L'Espèce Humaine," by a very eminent man, M. de Quatrefages. He is a gentleman who has made these questions his special study, and has written a great deal and very well about them. He has always maintained a temperate and fair position, and has been the opponent of evolutionary ideas, so that I turned with some interest to his work as giving me a record of what I could look on as the progress of opinion during the last twenty years. If he has any bias at all, it is one in the opposite direction to which my own studies would lead me. I cannot quote his words, for I have not the book with me, but the substance of them is that the proposition which I have just put before you is one the truth of which no rational person acquainted with the facts could dispute. Such is the difference which twenty years has made in that respect, and, speaking in the presence of a great number of anatomists, who are quite able to decide a question of this kind, I believe that the opinion of M. de Quatrefages on the subject is one they will all be prepared to indorse. Well, it is a comfort to have got that much out of the way. The second direction in which I think great progress has been made is with respect to the processes of anthropometry, in other words, in the modes of obtaining those data which are necessary for anthropologists to reason upon.

Like all other persons who have to deal with physical science, we confine ourselves to matters which can be ascertained with precision, and nothing is more remarkable than the exactness which has been introduced into the mode of ascertaining the physical qualities of man within the last twenty-five years. One cannot mention the name of Broca without the greatest gratitude; and I am quite sure that, when Prof. Flower brings forward his paper on cranial measurements on Monday next, you will be surprised to see what precision of method and what accuracy are now introduced, compared with what existed twenty-five years ago, into these methods of determining the physical data of man's structure. If, further, we turn to those physiological matters bearing on anthropology which have been the subject of inquiry within the last score of years, we find that there has been a vast amount of progress. I would refer you to the very remarkable collection of the data of sociology by Mr. Herbert Spencer, which contains a mass of information useful on one side or the other in getting toward the truth. Then I would refer you to the highly-interesting contributions which have been made by Prof. Max Müller and by Mr. Tylor to the natural history of religions, which is one of the most interesting chapters of anthropology. In regard to another very important topic, the development of art and the use of tools and weapons, most remarkable contributions have been made by General Lane Fox, whose museum at Bethnal Green is one of the most extraordinary exemplifications that I know of the ingenuity, and, at the same time, of the stupidity of the human race. Their ingenuity appears in their invention of a given pattern or form of weapon, and their profound stupidity in this, that, having done so, they kept in the old grooves, and were thus prevented from getting beyond the primitive type of these objects and of their ornamentation. One of the most singular things in that museum is its exemplification—the wonderful tendency of the human mind when once it has got into a groove to stick there. The great object of scientific investigation is to run counter to that tendency.

Lastly, great progress has been made in the last twenty years in the direction of the discovery of the indications of man in a fossil state. My memory goes back to the time when anybody who broached the notion of the existence of fossil man would have been simply laughed at. It was held to be a canon of paleontology that man could not exist in a fossil state. I don't know why, but it was so; and that fixed idea acted so strongly on men's minds, that they shut their eyes to the plainest possible evidence. Within the last twenty years we have an astonishing accumulation of evidence of the existence of man in ages antecedent to those of which we have any historical record. What the actual date of those times was, and what their relation is to our known historical epochs, I don't think anybody is in a position to say. But it is beyond all question that man, and not only man, but, what is more to the purpose, intelligent man, existed at times when

the whole physical conformation of the country was totally different from that which characterizes it now. Whether the evidence we now possess justifies us in going back further, or not—that we can get back as far as the epoch of the drift is, I think, beyond any rational question or doubt; that may be regarded as something settled—but when it comes to a question as to the evidence of tracing back man further than that—and recollect drift is only the scum of the earth's surface—I must confess that to my mind the evidence is of a very dubious character.

Finally, we come to the very interesting question—as to whether, with such evidence of the existence of man in those times as we have before us, it is possible to trace in that brief history any evidence of the gradual modification from a human type somewhat different from that which now exists to that which is met with at present. I must confess that my opinion remains exactly what it was some eighteen years ago, when I published a little book [1] which I was very sorry to hear my friend Prof. Flower allude to yesterday, because I had hoped that it would have been forgotten among the greater scandals of subsequent times. I did there put forward the opinion that what is known as the Neanderthal skull is, of human remains, that which presents the most marked and definite characteristics of a lower type—using the language in the same sense as we would use it in other branches of zoölogy. I believe it to belong to the lowest form of human being of which we have any knowledge, and we know from the remains accompanying that human being that, as far as all fundamental points of structure were concerned, he was as much a man—could wear boots just as easily—as any of us, so that I think the question remains pretty much where it was. I don't know that there is any reason for doubting that the men who existed at that day were in all essential respects similiar to the men who exist now. But I must point out to you that this conviction is by no means inconsistent with the doctrine of evolution. The horse which existed at that time was in all essential respects identical with the horse which exists now. But we happen to know that going back further in time the horse presents us with a series of modifications by which it can be traced back from an earlier type. Therefore it must be deemed possible that man is in the same position, although the facts we have before us with respect to him tell in neither one way nor the other. I have now nothing more to do than to thank you for the great kindness and attention with which you have listened to these informal remarks.—*Nature.*

[1] "Evidence as to Man's Place in Nature."

MONERA, AND THE PROBLEM OF LIFE.

By EDMUND MONTGOMERY, M. D.

III.—THE PHYSICAL PHASE OF THE PROBLEM.—(*Concluded.*)

IT has been shown in former articles that living motion is the result of alternate expansion and contraction on the part of the protoplasm; and we could not fail to perceive that this occupation of so much more or so much less space is the physical property of the protoplasm under different states of chemical composition. It remains to be ascertained by what agencies the chemical composition and decomposition of the living substance are affected. What are the influences that disintegrate the protoplasm? and what are the influences that reintegrate it?

A little attention to the visible changes which occur in the expanding material of different monera, when being checked in its onward course, soon demonstrates that it is the resistance of the medium, the counteraction of the energies composing the immediate environment, which causes chemical rupture in the organic substance. The molecule of protoplasm, like all very high compounds, and, in fact, like almost all nitrogenous compounds, is in a considerable degree explosive. During the expansion of the protoplasm, the medium is pushing against it with a force of its own; and it is this opposing energy, exerted by the medium, which, at some definite moment of its increasing composition and consequent expansion, causes this living substance at last to explode.

No unscientific conjecture has been allowed to enter into the above conception of this highly-important vital occurrence. It is as a mental sketch, in its outline, as positive and certain as any fact of Nature can possibly be.

In observing this process of decomposition, first the outer envelope of the projecting cone is seen to become disintegrated, and, in lower monera, also solidified. In these lower specimens the expanding material pushes still onward along the central axis of the cone, breaking through its apex, until it is at last also overcome by rigidity.

As the expanding material is perfectly translucent, the slightest optical change in it can be easily detected. The whitish, somewhat more opaque appearance of the stagnating protoplasm indicates that an important molecular alteration has taken place. That this alteration is of a chemical nature is actually proved by the products of decomposition being in many instances visibly gathered into a separate globule.

Thus the dynamical energy of the medium applies the match, gives the turning-stroke to the pending explosion, and it is by this dynami-

cal act that the specific chemical rupture is effected, in consequence of which the protoplasm reassumes its former contracted state in space.

In physiology, the peculiar activity displayed by the protoplasm, and induced by the dynamical influence of the medium, is called the function of the acting substance. The function is said to be stimulated by the dynamical influence, and the material compounds which separate from the living substance during this operation are distinguished as products of functional disintegration.

The special function of living contraction, which we have been enabled so plainly to follow up in our primitive organisms, is typical of all motor and sensory functions whatever. Contractility is the fundamental expression of vital function. It is the first unmistakable, distinctly visible manifestation of living activity.

All these functional performances, these visible and otherwise directly sensible parts of organic activity, compose the open spectacle of life—the ostensible conspicuous display of vitality. They correspond to the manifest figurative exhibitions of an exquisitely-contrived clock, all set in motion during its unwinding. But beyond this variegated automatic show perceived on the outside, what depths of unsolved mystery, molecular and other, remain behind in the impenetrable recesses of organization, affording a boundless field for scientific exploration, as well as teleological speculation.

All those of the past and present who, in the stronghold of final causes, have fortified their faith in a spirit of guiding forethought—Voltaire, the sprightly scoffer, with Paley, the sifting advocate, and so many more who have sought to interpret the secret scheme of apparent design traceable in the all-befitting coaptation of things—to me it seems they have but slightly and superficially used their strong means.

The wonder lies essentially in the unification and integration of manifold influences into the compass of one single individual entity, not so essentially in the subsequent spontaneous correlation of that individual to those manifold influences. The wonder lies chiefly in the concentrated and unified organization of the relations, not so much in their functional display afterward. The problem is the established unity of the multifariously related individual, not the planning and fitting of these multifarious relations themselves. The power of our life is intrinsically wrought, not extrinsically derived.

This most weighty truth the science of organization maintains not on mere general grounds or formal conclusions drawn from assumed premises, but it is ready to prove it step by step by actual verification. The subsistence of the reverse supposition is altogether emotional and metaphysical; it rests on fictitious ontology. From foreign spheres an outside hand of power is made to reach forth, and to set going, by dint of will or deed, the precious clock of life, with all its play of sensation and motion, its revealing and its conquering beats. From out the indefinite infinitudes an unlimited skill is evoked, and upon it are im-

posed the effortless contrivance and accomplishment of all that is so laboriously painful, joyful, marvelous to us.

This, in its best sense, means blind surrender of all knowledge to implicit trust. But life, grown conscious amid incessant struggle and remorseless fate, feels now sufficiently inured and emboldened not to shrink from prying with utmost earnestness into the secret of its own significance. It yearns to comprehend.

However, one obstacle removed, another at once takes its place. It so happens, namely, that we ourselves are most ingenious contrivers, all of us inveterate mechanists from our birth, using with much advantage things that already are. And, very likely, because of such universal human propensity, the advanced thinkers of our race conceive that a chaos of some kind of original stuff must have served a similar purpose to an infinitely mightier contriver, maker, Nature, or whatever special appellation anthropomorphic or metaphysical predilection may dictate for it. Poor philosophy this, that has to beg the entire question. No, we are very far yet from having solved the riddle of final causes and natural synthesis. We stand on the outside, perplexed as ever, in spite of Hume's concentrative naturalism, and Kant's schools of criticism and transcendentalism. No word of prophetic speech, or weighing knowledge, has yet uttered the true meaning of things. Our mind, with its shallow dip, emotional and mechanical, does but pierce the rippling face of creative profundity.

One point, however, one steadfast point, is everywhere discernible among the phantasmal shifting of appearances and thoughts; and this one positive element of truth thus enunciates itself: Only by unremitting, infinitely graduated, indwelling travail, does at all times the fruit of existence receive its birth. The import of this guiding truth can be but superficially reprojected and numerically symbolized by the recognition of signs of inorganic evolution, and the heaping of ages upon ages of geological time. Its real value can be realized only by the discovery and penetration of its actual source of emanation—organization.

Perhaps our monera will materially assist us in gaining some estimate of the potency of organization. In its adequate composition will consist the arduous task of the philosophy of the future.

The study of moneric protoplasm has disclosed that so-called contractility is not merely a property of the living substance, but that it is its function, stimulated by the dynamical influences of the medium, and effected by means of chemical disintegration. The organic molecule, before it experienced its chemical, its functional rupture, was held together by the bond of inwrought chemical affinities. Now that dissociation has been accomplished, these chemical affinities are left unsatisfied. The disintegrated protoplasm forms but one complemental part of a higher, most definite combination. If the other complemental part should happen to be in readiness somewhere, and be brought, by some means or other, into actual contact with the mutilated protoplasm,

then surely the existing affinities would exert their influence, and the higher compound would be restored in its former integrity and completeness. This—expressed in the language of chemistry—is exactly what in reality occurs.

The union of the disintegrated protoplasm with complemental material, furnished by the medium, can be directly witnessed without any possibility of misapprehension. We see the disintegrated protoplasm. We see it combine with substances drifted to it by the medium, and we see it in consequence reassume its former state.

Now, at last, we have actually entered the threshold of organization. We have discovered the fundamental fact of its statics. We know positively that reintegration of the living substance, restoration of the disturbed vital equilibrium, is the work of preëstablished chemical affinities, and that it requires extraneous matter of a specific kind to enable this restitution to take place.

The statical aspect of all organization offers nothing but a complication of this one event of chemical equilibrium, a vast complication in the molecular gradations of functionally disintegrated protoplasm, a vast complication also in the gradations of restitutive material.

The integration and differentiation of vital function on the one hand, and the preparation and composition of food-material on the other hand, form—as we will become fully aware further on—the two great divisions in the subject-matter of the science of organization, divisions corresponding to the fundamental biplicity of all advanced organization, its animal and its vegetative life. Organization in the sphere of animal life is the expression of the development of manifold outside relations in the vital unit. Organization in the sphere of vegetative life is the expression of the preparation of more and more elaborate material, fit to restore the functional waste of those developed relations.

I believe no candid critic can deny that the above related observations have laid open to inspection the secret mechanism of life; have reduced to the domain of operations known in the inorganic world the performances that, in a primitive state of life, visibly constitute vital activity.

With little more mental exertion than is required for the faithful interpretation of obvious appearances, a scientific feat has been accomplished which but yesterday seemed totally impracticable. I am aware that, on account of its strange simplicity, many will deem that, after all, not much advantage has been gained by it. But let no one deceive himself in this. By dint of this internal as well as external understanding of motility, we know at this very moment more, much more, about the property of life in the living substance than we do of any other property belonging to any other substance.

We clearly conceive the manner how, and the conditions by which, motility, this most prominent vital manifestation, constitutes an inher-

ent property of the living substance. Do we as yet comprehend in the same way the intimate modes of activity which constitute the properties appertaining to inorganic substances? Is any kind of those peculiar motions which form the scientific essence of the various forces of inorganic Nature so strictly and deeply intelligible as has now become that specific motion which forms the scientific essence of the force of life?

Motion of any kind stands at present just in the same relation to dead matter as that special mode of motion called contractility stood, before this, to living matter. Mechanical motion, heat, electricity, etc., are all qualities occultisimal, known only by the relative measurement of the spaces of contraction and expansion which their manifesting substrata occupy, or are thought to occupy.

Comparative expansion and contraction are, and must be, the subject-matter of all quantitative science. All intensities are made quantitatively scientific by being "converted" into modes of space. Time itself is thus measured, and the intensity of heat can be ascertained only by the expansion and contraction of the manifesting substances. So with all. Our undulatory theories are expressions of the same helpful makeshift; an expanding and contracting substratum.

Motility is precisely such another expansion and contraction. But, now, we know not merely the fact. We know, besides, how it is effected. We know something about the working of it within the manifesting substance. By this qualitative penetration, this more substantial insight into natural operations, we have broken the consolidated crust of mere superficial shiftings in space, and have forced a scientific entry into deeper spheres of knowledge.

The comparisons between motility and other modes of motion are strictly appropriate. How much so cannot be adequately appreciated until the origin and development of sensation have been traced; of which all modes of motion are, in the last instance, accurately corresponding affections or reactions.

And, now, what has become of this most vexed problem of problems—the origin of life? Is not protoplasm a chemical compound like other substances, merely varying from them in its degree of molecular complexity? Its most characteristic manifestation, its distinguishing mode of motion, its peculiar force—the one specific activity constituting its most vital difference—is better known to us than any quality which forms the distinguishing feature between other substances. Do we greatly concern ourselves about the origin of MgO,SO_3+7H_2O, or any other mineral substance? Why, then, should the origin of some combination of C, H, N, O, be made a question of the life and death of our principal philosophies? Has it actually come to this, that the scientific foundation of our creed rests on the decision whether COO is or was once changed into CHO by natural or supernatural means; and this when there is plenty of H about in our world? Yes, it is even so,

however incredible, however little flattering to our intellectual pretensions. The contending claims of naturalism and supernaturalism, the fate of the most momentous question touching the guidance of our life, turn actually, in the field of science, upon the paltry issue of the synthesis of ternary carbon compounds, whether this be chemically or whether it be superchemically effected. COO is undisputably an inorganic compound. CHO is undisputably an organic compound. This designates accurately the actual depth of the gulf existing between organic and inorganic Nature.

The chief vital manifestation of protoplasm, its contractility, can no longer startle us, for we know exactly how it is produced by well-known chemical and physical means. The combination of C, H, N, O, constituting protoplasm, is nothing but a very complicated chemical compound. CHO is a less complicated compound. COO is a still less complicated compound.

We do not in the least know how COO originates. We know a little better how CHO originates. And, perhaps, it will presently appear that we know still better how the combination of C, H, N, O, constituting protoplasm, originates. The advantage of intelligibility lies all on the side of organic Nature. It is astounding to contemplate in what a degree this may actually prove to be the case.

We owe an incalculable debt of gratitude to quantitative science. In our panic-stricken minds it has established the certainty of serene order everywhere. Through the never-failing verification of inflexible laws it attests the necessary connection and absolute interdependence of all accessible changes in Nature. Thus it has liberated us from a thralldom infinitely more pitiful than any form of common slavery—the thralldom of our own vicious and cruel superstitions. In many ways it has enriched our lives a thousand-fold, and we may, in future, expect from it an ever-increasing harvest of similar benefits.

It appears to me as if I could discern with some degree of distinctiveness—just beginning to loom in the distant twilight of consciousness—an entirely new era of knowledge; an era governed by the science of organization, by means of which more concentrative appreciation the synthesis of reality will receive a deeper explanation, and all facts of Nature appear in an organic light, in a qualitative interdependence, evolution being then understood as creative evolution, and not as mere transformation of modes of motion and atomical redistribution of matter. I have conjured up into the medium of shadowy words this most vague fancy of an organic epoch in science, because I firmly believe that we are already in possession of a clew to the means and ways by which the development of the living substance has been and is still being achieved; while, on the contrary, we possess no clew whatever to the means and ways which have led to the development of the now existing inorganic substances from the supposed primordial substratum.

We watch a moner for hours, for days. There it is, ever continuing

without intermission to expand and to contract; alternately to suffer decomposition and to accomplish its recomposition. A blank sameness, an almost thought-paralyzing monotony of life, is thus exhibited by many of these primitive beings. Only always expansion and contraction, by means of that same kind of reintegration and disintegration. Nothing more, apparently. It would almost seem as if the anti-evolutionists were right after all in their main view of life. It, indeed, resembles most strikingly a perpetual seesaw; the very same thing always over again—a mere organic toy, ingeniously contrived, so as to maintain itself intact, in spite of encroaching outside influences; the unmeaning disturbance of a most delicate equilibrium, and the following exact reëstablishment of that very same equilibrium. This, reduced to its most simple biological expression, is the foundation of the opinions which oppose evolutionism by maintaining the permanence of organic species, or their archetypal origin.

All turns upon the decision of the following point: Does there exist an absolute equivalence, a total identity between the compound separated from the protoplasm by the dynamical influences of the medium and the restitutive compound taken up from the medium by dint of the specific affinities inherent in the protoplasm? Does there normally exist a complete fixity in the observed play of equilibrated activities? Does this ever-reiterated exhibition of motility fulfill only its own motory object? Or, translated into the language of volition, Does the organism merely move to feed, and feed to move? This, in truth, is the pith of this momentous question.

The chemical affinities inwoven in the protoplasm are, like all chemical affinities, of a most definite kind. This chemical definiteness is even outwardly manifest in the strict preservation of all peculiarities in the different living substances which constitute the varieties of monera. Now, this functional restitution of protoplasm is effected entirely by means of these inherent chemical affinities. It is clear, therefore, that, if a deviation is ever to occur in the beats of this chemically so firmly established vital pendulum, it can be operated only in two ways: Either the dynamical influences succeed in splitting off from the expanding protoplasm a slightly-differing molecule, affecting thus the total chemical equilibrium in such a manner as to bring about a somewhat altered reintegration of the same, or the restitutive material possesses, by dint of its own peculiar molecular composition, the power of forcing the disintegrated substance to reintegrate itself with some slight deviation.

In other words, variations in the molecular constitution of the protoplasm can only be effected either by the dynamical influences of the medium, or by the restitutive material of the medium. Spontaneous variations, starting from within the already-established molecular equilibrium of the protoplasm itself, would be like all other spontaneous changes, an inadmissible supposition, an effect without a cause.

In another stage of the inquiry we will learn the exact effect which restitutive material, when not accurately complemental, does actually exert on the protoplasm. I will here only mention that it has, very demonstrably, only the power specifically to deteriorate the same, and not in the least the power to give it any impulse toward higher development. In the course of organic progress it is the living substance which lifts the food to the level of its own requirements; not the food which confers higher vital powers on the protoplasm.

There remains only one path, then, through which development can make its entry into the living substance, and this is—be it fully understood—the infinitely toilsome elaboration of molecular complexity by means of ever-reiterated functional disintegration. If it, namely, should happen, that the dynamical influences of the medium are so attuned as to shift and complicate—by force of their sundry specific modes of operation—the molecular equilibrium of the protoplasm, ever so immeasurably little at a time, then, by incessant perseverance, an appreciable organic effect may, at last, be attained.

There are strong reasons which make it highly probable—I do not say certain, because it lies in the nature of the process that it cannot be directly witnessed—but there are manifold occurrences which make it very evident that this mode of development is actually the one adopted in Nature.

In a general way we all know, with perfect certainty, that previous functional exercise of an organ fits the same all the better for further functional performances. Use develops functional structure; disuse involves its atrophy. All educational acquirement rests on this foundation, and also all degradation of skill or culture.

We will endeavor to form some mental representation of the activities which are elaborating these great and evident results.

The energy of the dynamical influences is exerted on protoplasm in the course of chemical composition. It is a substance in process of molecular cumulation which encounters, in its onward flow, the forces of the medium. The foremost part of an advancing conical projection, for instance, will consist of higher material than its lateral part, and will therefore be differently affected even by the same forces of the medium. But, if we further take into consideration that the influences of the medium are themselves of a manifold nature, each kind affecting the protoplasm with a specific energy of its own, it can be readily conceived that a most complicated molecular disturbance must ensue. This must be all the more the case in a substance in which the forces of the medium have not each their definite, circumscribed, and attuned channel of functional stimulation; but are attacking more or less every part of its circumference.

Dynamical considerations, too abstruse to be here introduced, make it extremely probable that a preponderance of effect in favor of the dynamical energies best attuned to the highest, foremost portion of

the expanding living substance will give rise to a restitution of the entire mass more in the likeness of the higher protoplasm disintegrated by the more subtile dynamical influences. Thus the constitution of the protoplasm at the very beginning of its next pulse of recomposition will, by this slight increment of complication, resemble a whit more its molecular state, when at the height of its former expanding pulse. The decomposition caused by the combined specific energies of the medium will be followed by a somewhat higher composition.

The elaboration of organic substances in plants is at all times notably effected by a process similar to the one here indicated. It is brought about by a twofold chemical activity, incited by a specific dynamical influence of the medium. First there occurs a specific decomposition, and then, in consequence, a somewhat altered recomposition; or, technically expressed, there occurs reduction followed by substitution. It is believed that under the influence of light there is split off from carbonic acid one atom of oxygen, which is then replaced by one atom of hydrogen: $_{3}COO+H_{2}O-C_{3}H_{2}O_{3}+OOO$.

But, before examining the conditions under which this fundamental and most weighty transformation of the inorganic into the organic takes place, I will state, in further support of the gradual development of the living substance, that the phenomenon of individual growth gives in itself plain evidence of organic development having actually occurred in the past. Growth is essentially a concise recapitulation of developmental changes.

But, not to complicate matters too much, I have here purposely left out of consideration all manifestations appertaining to growth, as well as those appertaining to propagation. Both these phases of organic existence do not belong to the domain of production, but entirely to that of reproduction. Propagation multiplies, growth reconstructs, organic results previously achieved.

Though it cannot be denied that the attentive observation of moneric protoplasm has restricted the physical phase of the problem of life to the limits of a purely chemical question, and though it may be conceded that organic development is truly effected by means of chemical activity dynamically incited, yet with many there will persist an ungratified curiosity concerning the origin of life. This dissatisfaction, expressed in clear words, can only amount to the following objection: "Granting that motility is merely the scientifically intelligible property of a specific chemical compound, yet it has not been shown how on our planet the first organic compound has actually started into existence."

Against this rather radical claim on the science of life might be urged, that we do not precisely know how, for instance, carbonic acid has naturally originated. But we will be told that one has only to bring carbon, under certain known conditions, together with oxygen, and that then carbonic acid will invariably result.

To this might again be replied that organic substances can also be

made to originate in the same manner; that from inorganic material Woehler produced urea, Strecker taurin, Kolbe acetic acid, etc.

However, I am perfectly aware that this is not the kind of information which will satisfy the somewhat unscientific but historically justifiable craving for positive and circumstantial enlightenment concerning the origin of living substance. The desire is to understand the genuine organic synthesis which has legitimately led to the formation of such peculiar compounds as now actually manifest vital phenomena.

With the protest, clearly defined, and well sustained in these pages, that this question is not at all one of vitality, but merely one of specific chemistry, I will venture a few tentative gropings. Their verification would constitute not a biological but a purely chemical task.

The transformation of the inorganic into the organic world is at present, so far as we are aware, exclusively accomplished by the mediation of protoplasm, containing that peculiar kind of coloring-matter to which the greenness of vegetation is due, and which has received the name of chlorophyl. This chlorophyl-tinged protoplasm is the substratum in which carbonic acid is deprived of its oxygen, and organically incorporated. Here, and here alone, organic substance originates in Nature.[1] It is the one magic gate through which the inorganic effects its passage into the organic; the one transubstantiating medium by which the death-like spell of inertness is broken and the dormant energies of matter admitted to bloom forth into life.

By what agencies is this stupendous chemical feat, this vivifying transmutation, wrought? How is so signal a synthesis of material constituents dynamically incited? If we possessed no further knowledge concerning this initial shaping of organic compounds, it might be supposed that the chlorophyl-tinged protoplasm exerted some kind of catalytic influence on carbonic acid, causing by its mere presence decomposition of the same, and affording thereby to the free carbon an opportunity of entering into the organic nexus. But it is far otherwise—exceedingly more wonderful.

Prompted by Priestley's discovery of oxygen—the vivifying gas inhaled by animals and exhaled by plants, and its contrast to carbonic acid, the suffocating gas exhaled by animals and inhaled by plants—the entire scientific world, during the first decades of the present century, became deeply agitated by the recognition and elucidation of what was called the chemical and physiological balance of organic Nature."

It was taught—and to the present day this teaching forms the groundwork of most physiological conceptions—that plants imbibe and

[1] The experimental synthesis of organic compounds, found to be accomplished, under certain artificial conditions, by normally parasitic organisms, containing no chlorophyl, need not be taken into consideration in the above argument, however interesting in itself it may otherwise prove to be.

reduce carbonic acid furnished by animals, forming therefrom organic compounds of high calorific value; and that these food-compounds reunite in the animal with the oxygen inhaled by it, yielding by this combustion all the power exhibited in its vital manifestations.

While this—from our present point of view—fundamentally erroneous and most misleading conception exerted an all but universal sway over scientific minds, it happened that, under its influence, so early as 1844, our illustrious and veteran scientist and philosophical historian, Dr. John W. Draper, succeeded in establishing, by a series of beautiful experiments, a far deeper and vastly more essential connection in Nature.

This connection, if I am not greatly mistaken, is destined to become the redeeming thread by which Science will extricate itself from the mechanical maze of rigid resistance and equivalent mass-motion. By dint of so significant and mathematically available a clew, it may in time reach a somewhat more commensurate recognition of effects synthetically secured, of inherent cumulative elaboration, the unforfeitable boon of specific dynamical influences, which with restless toil are ever busy, widening the scope of qualitative wealth, intensifying the intestine sensitiveness and sympathetic response by which substances inwardly answer the inward call of other substances.

The marvelously slender thread of vivifying connection, traced to its origin by Draper, is an ethereal but most definite band of vital dependence, absolute dependence. It is a truly promethean beam, for without it no life, no fire on earth. You suppress from the entire amount of solar influence—calorific, luminous, and chemical—solely the yellow rays, and you have quenched life at its starting-point: no more elaboration of organic compounds by chlorophyl-protoplasm, no more food-supply, no more vitality. You have cut off the thread of life, the golden band of union by which the still embryonic vitality of our planet receives sustenance from the mighty parent-orb. This great discovery of Draper the recent researches of Sachs and Pfeffer have only essentially corroborated.

It is here, then, that the knot of organic complexity is being really tied in Nature, and this is, therefore, the exact point at which the mystery of organic synthesis has to be unraveled. A most specific dynamical influence meets here in a peculiar preëxisting substratum with certain inferior matter, and under this confluence of conditions, by a chemical process of reduction and substitution, molecular organization is effected.

In framing my hypothesis of the origin of organic compounds on our globe, I would closely adhere to the above facts. After what I have learned with regard to the yellow rays, I would not expect aboriginal organic synthesis to have taken place at the bottom of the sea, where all dynamical influences must be dispersed, or so suffused as to have lost their definite efficiency. I would then imagine some probable

preëxisting substratum—some compound of silicium, for instance. Silicium is evidently a very wonderful substance, strangely like carbon in many respects. It is capable of existing in at least as many similar molecular modifications; and, above all, some of its compounds, though inorganic, occur in the colloid state.

It would not be an extravagant supposition to assume a film of some such colloid compound of silicium floating on the top of the sea, exposed to specific solar influences, imbibing carbonic acid from the air, and being traversed by currents of sea-water, holding carbonate of lime and other salts in solution. Under such favorable circumstances it is not altogether improbable that carbon may have actually by degrees been chemically substituted for silicium, and that thus the first hydrocarbons were allowed slowly to slide into existence.

When we consider what a prominent part silicious and cretaceous organisms play in the history of our globe, it would not be so very astonishing to learn that the inorganic substance has to be looked upon as the original matrix, and not merely as the skeleton of such organisms.

There may have been an age in which silicium was the leading element, followed by an age in which lime ruled organic composition, followed again by an age in which Carbon and Company is the thriving firm, to be supplanted by an age in which nitrogen will be foremost, till this also is forced into the background by phosphorus, etc.

It would not be difficult to fill a volume with plausible reasonings in support of the above nevertheless completely hypothetical conceptions. Side by side with the great and positive truths revealed by the study of incipient motility, truths most scrupulously verified during years of closest application, I would have grudged such fanciful conjectures even the little space here allotted to them, if it had not been my intention to invoke their assistance by way of contrast.

It cannot be too forcibly impressed on all who take an earnest interest in science that we have constantly to bear in mind the radical difference obtaining between verified scientific results and analogical scientistic suggestions. The former represent tasks performed, the latter tasks imposed. The former constitute our accredited store of premises, on the ground of which we may with some safety indulge our reasoning propensities; the latter is the more or less skillful performance under such reasoning license. To reason from premises not verified as forming an integral part in the necessary enchainment of natural events is, however, to move in a world of thought in no way contiguous to the realm of science.

Whoever, therefore, wishes to form an opinion regarding the truths here advanced, whether they be in strict accordance with Nature, or whether they be merely mistaken interpretations, need only to examine monera for himself.

Motility is the key to the understanding of vitality and organization. With little trouble any one can now convince himself that living motion

is actually accomplished by the operations which I have here disclosed.

A certain organic substance expands under chemical composition, and afterward contracts under chemical decomposition. Its disintegration is incited by the dynamical influences of the medium; its reintegration is brought about by its own inherent chemical affinity, which affinitive power effects its combination with complemental material furnished by the medium.

In pursuing the inquiry here begun, the next step would be to show how complications of these sundry phases of the one central fact of motility lead to definite organization in various directions, and to the rise of sensation.

ELECTRICITY IN THUNDER-STORMS.[1]

By ELISHA FOOTE.

THE great development of electricity in thunder-storms has been a subject of much speculation. Its explanation, however, is still an unsettled question. Some views on this subject are presented in this paper.

We have no evidence that the production of fogs or clouds—the change from invisible to visible vapor, or from combined to uncombined moisture—produces any electricity. All experiments to establish such a supposition have had a negative result.

These particles of vapor we may suppose to be small spherules, each with its normal portion of electricity that surrounds or occupies the surface of the sphere. When two of these particles unite and form one, the combined particle will have twice the electricity of either of the separate parts, but not twice the surface. There will then be an accumulation of electricity upon the surface of the combined particle; and still more will this be so when thousands of these spherules unite to form a drop of water.

We may well conceive, therefore, that a cloud forming water should become surcharged with electricity, that will escape in violent explosions when the accumulation is too rapid or the circumstances are unfavorable to its being carried off by the surrounding moist air.

It is not, then, the formation of vapor, but its condensation to rain, that produces thunder and lightning. And this, it is believed, accords with all our experience. Clouds are constantly forming and disappearing; fogs and vapors are accumulated in some places in great abundance, but no electrical excitement has ever been observed. But, on the other hand, there is never a flash of lightning without a manifest

[1] Paper read before the Philosophical Society of Washington.

deposition of rain. To this there is no exception. There is, indeed, a manifest relation between the two. The more sudden and rapid the condensation, the more violent and terrific the explosion.

Sometimes, in thunder-storms we hear a loud crash, and then, soon after, comes an increased pouring down of water. Sound travels more rapidly than rain, and, although the report reaches us first, the interval between the events and the distance traveled plainly indicate that the explosion succeeded the condensation; and we naturally infer that it was caused by it. The loud crash and simultaneous lightning show the nearness of the explosion, at the origin of the rain-drops.

I next inquire whether we have experimental proofs corroborating these views.

A few years since an accidental escape of steam from a steam-boiler was found to strongly electrify a person who stood upon an insulator and held one hand in the escaping steam. This excited much interest at the time, and it was investigated by Armstrong and others, and led to our present steam-boiler electrical machine. The phenomena were at first supposed to throw much light upon the causes of atmospheric electricity. The subject was subsequently taken up by Faraday, who instituted a series of experiments, and came to a different conclusion. His theory, using his own words, was :[1]

"The electricity is due to the friction of the particles of water which the steam carries forward against the surrounding solid matter of the passage, . . . and is in its nature like any other ordinary case of excitement by friction."

Again (section 2145), he says :

"Finally, I may say that the cause of the evolution of electricity by the liberation of confined steam is not evaporation; and, further, being I believe friction, it has no effect in producing and is not connected with the general electricity of the atmosphere."

The great authority of Faraday has made this, ever since, to be the generally-accepted explanation of the phenomena. It may seem presumptuous to question it, but I cannot think that a careful examination of his experiments will justify all of his conclusions.

Faraday's apparatus consisted of a small steam-boiler, which he insulated, and for the discharge of steam he attached a pipe about four feet long, terminating in an iron globe. This had an orifice to which other appendages could be attached, and there was also a device for injecting water into the exit-pipe. His first experiments were directed to evaporation. He found that when the steam was at full pressure, and the valve was suddenly raised and taken out, and the evaporation was very rapid, no electricity was produced. He charged the boiler with electricity by an electrical machine before the valve was raised, and found that the escape of steam did not affect the charge. It was hence inferred that no electricity was produced by evaporation.

[1] "Researches in Electricity," vol. ii., section 2085.

The circumstances under which electricity was produced were the next subjects of his inquiry, and he says (section 2084):

"The issue of steam alone was not sufficient to evolve electricity. Attaching appendages to the globe, with no water in it, after a few moments and when the apparatus became hot, the issuing steam excited no electricity; but when the steam-globe was filled up with water so far that the rest of the condensed water was swept forward with the steam, abundance of electricity appeared. If then the globe was emptied of its water, the electricity ceased; but, on filling it up again to the proper height, it immediately reappeared in full force. So when the feeder-apparatus was used, while there was no water in the passage, there was no electricity; but, on letting in water from the feeder, electricity was immediately evolved."

It thus appears that, without water to condense the steam, there was no electricity, but with condensation an abundance appeared. Other experiments were to the same effect.

Faraday further says (section 2089):

"If there be no water in the steam-globe upon opening the steam-cock, the *first effect* is very striking: a good excitement of electricity takes place, but it very soon ceases. This is due to the water condensed in the cold passages producing excitement by rubbing against them. Thus, if the passage be a stopcock, while cold it excites electricity with what is supposed to be steam only; but as soon as it is hot the electricity ceases to be evolved; if then, while the steam is issuing, the cock be cooled by an insulated jet of water, it resumes its power. If, on the other hand, it be made hot by a spirit-lamp before the steam be let on, then there is *no* first effect. On this principle I have made an exciting passage by surrounding one part of the exit-tube with a little cistern, and putting spirits of wine or water into it."

Experiments with air were also made. It was compressed within a receiver and allowed to escape, impinging against ice or cones of wood or brass (section 2129). With common undried air electricity was produced. He says:

"This I attributed to the particles of water suddenly condensed from the expanding and cooled air rubbing against the metal or wood. Such particles were very visible in the mist that appeared, and also by their effect of moistening the surface of the wood and metal. . . . I proceeded to experiment with dry air (artificially dried by absorbents), and found that it was in all cases quite incapable of exciting electricity against wood or sulphur or brass in the form of cones; yet if in the midst of these experiments I let out a portion of air immediately after its compression, allowing it no time to dry, then it rendered the rubbed wood or brass negative. This is to me a satisfactory proof that in the former case the effect was due to the condensed water, and that neither air alone nor steam alone can excite these bodies, wood, brass, etc., so as to produce the effect now under investigation."

Under all circumstances, then, condensation produced electricity. Without it there was none. The theory of friction is wholly unnecessary to the explanation of the phenomena. It has to assume that water,

a conductor, rubbing against iron, another conductor, will accumulate electricity. But this is opposed to our experience. It requires friction with a non-conductor to excite electricity. We have instances daily of the passage of water through pipes, sometimes with great force and velocity. Did friction between the two excite electricity, it should be produced in great quantities. But no such effect has been observed.

Mr. Patterson, who experimented with the same boiler that Armstrong used, tried the effect of blowing out water instead of steam through a pipe from the boiler, and no electricity was thereby produced (*Philosophical Magazine*, vol. xvii., p. 459, 1840).

Were it indeed true, as Faraday assumed, that the friction of water against the sides of the exit-pipe produced electricity, it would be conducted away as fast as formed by the metallic tube to the negative boiler. Indeed, when he placed in the tube any saline or acid substance that increased the conducting power of water, no electrical effects were obtained. In some cases negative electricity, like that of the boiler, was manifested.

I do not find, from an examination of Faraday's paper, that he made any experiment upon steam at a distance from its exit, where its condensation to water mostly took place. His mode of experimenting he describes as follows. He says (section 2082):

"When the issuing steam produces electricity, there are two ways of examining the effect. Either the insulated boiler may be observed or the steam examined; but these states are always contrary one to the other. . . . To examine the state of the boiler or substance against which the steam is excited, is far more convenient, as Mr. Armstrong has observed, than to go for the electricity to the steam itself. And in this paper I shall give the state of the former, unless it be otherwise expressed."

I infer, therefore, that, in all the experiments hereinbefore detailed, the tests for electricity were made at or near the boiler, and the very important inquiry of the electrical effects at a distance, where condensation alone was concerned, seems not to have attracted his attention. This point, however, has been fully investigated by others.

Mr. Patterson attached ten or twelve pointed wires to a copper rod. These were bent downward and held in the escaping steam. He says (ibid., page 458):

"The sparks were larger when the points of the conductor were held in the steam about two feet above the valve; but large sparks were obtained by holding the conductor entirely out of the cloud of steam and at a distance from it, for the air in the wooden shed in which we operated became speedily electrical throughout. The electricity was positive."

Mr. Armstrong also states (ibid., page 453):

"Upon trying the steam in the first instance by the method adopted in the previous cases, that is to say, by standing upon an insulated stool and holding with one hand a light iron rod immediately above the safety-valve while the

steam was freely escaping, and then advancing the other hand toward any conducting body, sparks of about an inch in length were obtained. But it was soon observed that, by elevating the rod in the steam, the electricity was gradually increased, and that the maximum effect was not obtained until the end of the rod was raised five or six feet above the valve, at which point the length of the sparks occasionally reached two inches. Small sparks were even obtained when the rod was wholly removed from the steam and held in the atmosphere at the distance of two or three feet from the jet; and the electricity thus drawn from the air was positive like that of the steam. When the rod was extended into the cloud of vapor which accumulated in the upper part of the shed, electricity was drawn down as by a lightning-conductor from a thunder-cloud."

These results seem to me to point out very clearly the cause of the electrical excitement. If it were the friction of steam against the sides of the exit-pipe, then at that point should be the greatest manifestation. If, on the contrary, it be condensation, then at a distance from the exit, where the greatest condensation takes place, should be the greatest development—and such is the fact. At the valve, Faraday found no electricity. At five or six feet from it, according to Armstrong and to Patterson, its development was abundant. The conclusion seems to me inevitable. All the facts point to condensation as the cause of the excitement.

A phenomenon that occurs daily at Pike's Peak has been described to me. The tops of the mountain are covered with perpetual snow. During the summer months the snow-line gradually recedes up the sides of the mountain, and from it flow considerable streams of water, that are finally lost in the plains below. The winds coming from the prairies take up this moisture, and, ascending the mountain, reach the frozen regions above. At about eleven o'clock each day, black clouds begin to gather about the tops of the mountain, and soon thereafter pour down floods of rain. Flashes of lightning are almost incessant, with peals of thunder that seem to shake the mountains. I am informed that we have nothing in Eastern States that can compare with the terrific violence of these storms.

Here, certainly, is no friction, but condensation on a large scale; and it is attended with the same electrical effects that were observed in the condensation of steam from the steam-boiler.

Volcanoes sometimes emit great volumes of steam and smoke, and these are usually attended with flashes of lightning in every direction. Were the electricity due to friction, it would be found at the mouth of the crater, where the steam issues; but, instead of that, it is found on the sides of the column, where the steam meets with colder air, and is condensed to water. The effects are analogous in every respect to those of steam from the steam-boiler.

In thunder-storms we have no friction, but condensation, and we need not go beyond the usual effects of condensation to explain all the electrical phenomena.

CONSCIOUSNESS UNDER CHLOROFORM.

By HERBERT SPENCER.

A UNIVERSITY graduate, whose studies in psychology and philosophy have made him an observer able to see the meanings of his experiences, has furnished me with the following account of the feelings and ideas that arose in him during loss of consciousness and during return to consciousness. My correspondent, describing himself as extremely susceptible to female beauty, explains that "the girl" named in the course of the description was an unknown young lady in the railway-carriage which brought him up to town to the dentist's. He says his system resisted the influence of chloroform to such a degree that it took twenty minutes to produce insensibility: the result being that for a much longer time than usual he underwent partial hyperæsthesia instead of anæsthesia. After specifying some dreadful sensations which soon arose he goes on to say: ". . . . I began to be terrified to such a wonderful extent as I would never before have guessed possible. I made an involuntary effort to get out of the chair, and then—suddenly became aware that I was looking at nothing: while taken up by the confusion in my lungs, the outward things in the room had gone, and I was 'alone in the dark.' I felt a force on my arm (which did not strike me as the surgeon's 'hand,' but merely as an external restraint) keeping me down, and this was the last straw which made me give in, the last definite thing (smell, sound, sight, or touch) I remembered outside my own body. Instantly I was seized and overwhelmed by the panic inside. I could feel every air-cell struggling spasmodically against an awful pressure. In their struggle they seemed to tear away from one another in all directions, and there was universal racking torture, while meantime the common foe, in the shape of this iron pressure, kept settling down with more and more irresistible might into every nook and crevice of the scene. My consciousness was now about this: I was not aware of anything but an isolated scene of torture, pervaded by a hitherto unknown sense of terror (and by what I have since learned is called 'the unity of consciousness:' this never deserted the scene, even down to the very last inaudible heart-beat). Yet I call it a 'scene,' because I recognized some different parts of my body, and felt that the pain in one part was not the same as that in another. Meanwhile, along with the increased intensity of convulsion in my lungs, an element of noise had sprung up. A chaotic roaring ran through my brain, innumerable drums began to beat far inside my ear, till the confusion presently came to a monstrous thudding, every thud of which wounded me like a club falling repeatedly on the same spot. . . .

"From this stage my lungs ceased to occupy me, and I forget how

the struggle finished. There was a sense of comparative relief that, at any rate, *one* force was victorious, and the distraction over; the strange, large fright that had seized me so entirely when I felt myself ensnared into dark suffocation was now gone also, and there was only left the huge thudding at my ears, and the terribly impetuous stroke of my heart. The thudding gradually got less acutely painful, and less loud; I remember a recognition of satisfaction that one more fearful disturbance was gone. But, while the thunder in my ear was thus growing duller, all of a sudden my heart sprang out with a more vivid flash of sensation than any of those previous ones. The force of an express-engine was straining there, and like a burning ball it leaped from side to side, faster and faster, hitting me with such a superhuman earnestness that I felt each time as if the iron had entered my soul, and it was all over with me forever. (Not that 'I' was now any more than this burning-hot heart and the walled space in which it was making its strokes: the rest of 'me' had gone unobserved out of focus.) Every stroke produced exquisite pain on the flesh against which it beat glowing, and there was a radiation, as from a molten lump of metal between inclosures. Presently the unbearable heat got less, and there was nothing remaining except a pendulous movement, slackening speed, and not painful. Of nothing beyond was I conscious but this warm body vibrating: not a single other part of me was left, and there was not a single other movement of any sort to attract my attention. A fading sense of infinite leisure at last, in a dreamy, inaudible air; then all was hushed out of notice.

". . . . There was the breaking of a silence that might have been going on forever in the utterly dark air. An undisturbed, empty quiet was everywhere, except that a stupid presence lay like a heavy intrusion *somewhere*—a blotch on the calm. This blotch became more inharmonious, more distinctly leaden; it was a heavier pressure—it is actually intruding farther—and, before almost there was time to wonder feebly how disagreeable was this interruption of untroubled quiet, it had loomed out as something unspeakably cruel and woful. For a bit there was nothing more than this profoundly cruel presence, and my recognition[1] of it. It seemed unutterably monstrous in its nature, and I felt it like some superhuman injustice; but so entire had been the still rest all round before its shadow troubled me, that I had no notion of making the faintest remonstrance. . . . It got worse. . . . Just as the cruelty and injustice became so unbearable that I hardly could take it in, suddenly it came out a massive, pulsating *pain*, and I was all over one tender wound, with this dense pain probing me to my deepest depths. I felt *one* sympathetic body of atoms, and at each probe of the pain every single atom was forced by a tremendous pressure into all the rest, while every one of them was acutely tender, and

[1] If there were a noun belonging to the verb "To be aware of," like "recognition" to "recognize," it would be the one to use here.

shrank from the wound—only there was nowhere to shrink. A little before, I had merely *felt* the cruel element in helpless passivity; now, a still more crushing probe came; for an instant it forced all my atoms into one solid steel-mass of intense agony—then, when things couldn't go much farther, and all must be over, a sense of reaction emerged; there was a loosening, and I was urged into relief by uttering from my very depths what seemed not so much (at first) a piteous remonstrance as a piteous 'expression' (like an imitation) of the pain: in fact, the sense of woe had got also *outside*, and I *heard* it, a very low, infinitely genuine, moan. . . . The next second there was a change: hitherto it had been pain *partout*—now there came a quick concentration, the pain all ran together (like quicksilver), and I suddenly was aware that it was (localized) *up on the right;* while, simultaneously with this recognition of locality, a feeling of incipient *resistance* began to be in *other parts* (not that I felt them except just as *other* parts) of me from which the pain had receded. The pain itself was no less intense, rather more vivid, only I seemed to take it in a more *lively* manner: my uttering of a moan was no longer a mere faithful representation out into the air of what was inside me, but I had a slight sense of making an appeal for sympathy: to whom or to what I did not know, for there was no one or anything there. I was just going to utter a yet louder moan—as a fresh, fearful imposition of force plunged into me—when, there in front of me, to the *left* of my pain, was that girl, with those lovely ankles, and the graceful, Zingari brown stockings. . . . I felt, as distinctly as if some one had told me aloud, that I would not make any cry, that it was not the thing.

"Now came an agonizing, cold wrench, and two or three more successively, in such a hideously rough fashion, that the girl went, and everything was tortured out of me but the darkness and the gigantic racking, swaying torture which was excruciating my right side. An iron force, like a million-horse power, had hold of me, and I was being pulled upward and out of where I was, while I myself seemed another million-horse power which would *not* be pulled: the pain was something to be remembered. But up I came, the darkness got denser (I went so fast); it was vibrating, the dense agony vibrated faster; *I* was quivering, struggling, kicking out; everything was a convulsion of torture, my head seemed to come to the surface, a glimpse of light and air broke on the darkness, voices came through to me, and words; I recognized that a '*tooth*' was being slowly twisted out of my jaw, then I groaned imploringly, in true earthly style, as if this was *too much*, and I ought to be let alone now I was getting my head out; then I swallowed in air, made an exertion with my 'chest,' found my 'arms' were pressing something hard, grasped the 'chair,' and pushed myself up out in bewildered light, just as the dentist threw away the second right molar from the upper jaw."

Concerning this account it may be remarked, on the one hand, that

the higher consciousness seems not to have been wholly abolished; since there remained certain emotions and certain most general ideas of relation to objective agents. On the other hand, it is to be doubted whether the partial consciousness which the narrator had during anæsthesia is not, in the description, eked out in some measure by the ideas of his recovered consciousness carried back to them. Be this as it may, however, it is clear that certain components of consciousness disappeared and others became extremely vague, while a remainder continued tolerably distinct. And there is much significance in the relations among them: 1. There ceased earliest the sensations derived from the special senses; then the impression of force acting on the body from without; and, simultaneously, there ceased the consciousness of external space-relations. 2. There remained a vague sense of relative position within the body; which, gradually fading, left at last only a sense of those space-relations implied by consciousness of the heart's pulsations. 3. And this cluster of related sensations produced by the heart's action finally constituted the only remaining distinct portion of the *ego*. 4. In the returning consciousness we note first a sense of pressure *somewhere;* there was no consciousness of space-relations within the body. 5. The consciousness of this was not a cognition proper. In an accompanying letter my correspondent says of it: "'Recognition' seems to imply installation in some previously-formed concept (talking in the Kantian way), and this is just what was *not* the case:" that is, consciousness was reduced to a state in which there was not that classing of states which constitutes thought. 6. The pain into which the pressure was transformed was similarly universal instead of local. 7. When the pain became localized, its position in space was vague: it was "up on the right." 8. Concerning the apparition of "the girl," which, as my correspondent remarks, seems to have occurred somewhat out of the probable order, he says, in a letter: "I did not recognize her 'under any concept'—what I saw seemed to be almost unassisted intuition in the Kantian sense." 9. The localization of the pain was at first the least possible—the consciousness was of that part *versus* all other parts unlocalized.

These experiences furnish remarkable verifications of certain doctrines set forth in the "Principles of Psychology." This degradation of consciousness by chloroform, abolishing first the higher faculties and descending gradually to the lowest, may be considered as reversing that ascending genesis of consciousness which has taken place in the course of evolution; and the stages of descent may be taken as showing, in opposite order, the stages of ascent. It is significant, therefore, that impressions from the special senses ceasing early, leave behind, as the last impression derived from without, the sense of outer force conceived as opposed by inner resistance; for this we have seen to be the primordial element of consciousness. Again, the fact that the consciousness of external space disappeared simultaneously with the conscious-

ness of external force, answers to the conclusion drawn that space-ideas are built out of experiences of resistant positions, the relations among which are measured by sensations of muscular effort. Further, there is meaning in the fact that a vague sense of relative position within the body survived; since we concluded that by mutual exploration there is gained that knowledge of the relations among the parts of the body which gives measures through which the developed knowledge of surrounding space is reached. Once more we get evidence that the *ego* admits of being progressively shorn of its higher components, until finally the sensations produced by the beating of the heart remain alone to constitute the conscious self: showing, in the first place, that the conscious self, at any moment, is really compounded of all the states of consciousness, presentative and representative, then existing, and showing, in the second place, that it admits of being simplified so far as to lose most of the elements composing the consciousness of corporeal existence. Whence it is inferable that self-consciousness begins as a mere rudiment consisting of present sensations, without past or future. Lastly, we have the striking testimony that there exists a form of consciousness lower than that which the lowest kind of thought shows us. The simplest intellectual act implies the knowing something as such or such—implies the consciousness of it as like something previously experienced, or, otherwise, as belonging to a certain class of experiences. But we here get evidence of a stage so low that a received impression remains in consciousness unclassed: there is a passive reception of it, and an absence of the activity required to know it as such or such.

HALLUCINATIONS OF THE SENSES.

By Dr. HENRY MAUDSLEY

BY hallucination is meant, in scientific phraseology, such a false perception of one or other of the senses as a person has when he sees, hears, or otherwise perceives as real what has no outward existence—that is to say, has no existence outside his own mind, is entirely subjective. The subject is one which has special medical interest; but it will be seen to have also a large general interest, when it is remembered how momentous a part hallucinations have played sometimes at critical periods of human history. Take, for example, the mighty work which was done in the deliverance of France from English dominion by a peasant-girl of eighteen—Joan of Arc, the famous Maid of Orleans, who was inspired to her mission by the vision which she saw, and the commands which she heard, of St. Michael and other holy persons. Now, as there are few persons nowadays who believe that St. Michael

really appeared to this enraptured maiden, and as few, if any, will doubt that she herself sincerely believed that he did, one must needs suppose that her visions were hallucinations generated by the enthusiasm of a mind which was in a singularly exalted strain of religious and patriotic feeling.

The special medical interest of the subject lies in this—that there are a great many persons in the world who, suffering under some form or other of nervous disorder, habitually see figures or faces, hear threatening or insulting voices, even feel blows and taste poisons, which have no existence outside their own minds; and neither argument nor demonstration of the impossibility of what they allege they perceive will shake their convictions in the least. "You assure me," they will say, "that I am mistaken; that there are no such persons as I see, no such voices as I hear; but I protest to you that I see and hear them as distinctly as I see and hear you at this moment, and that they are just as real to me." What are we to reply? I have replied sometimes, that "as you are alone on one side in your opinion, and all the world is on the other side, I must needs think, either that you are an extraordinary genius, far in advance of the rest of the world, or that you are a madman a long way behind it; and, as I don't think you to be a genius, I am bound to conclude that your senses are disordered." But the argument does not produce the least effect.

Let me give an example or two of the character of these hallucinations, and of their persistence in minds that might be thought sane enough to correct them. The first shall be that of an old gentleman who was much distressed because of an extremely offensive smell which he imagined to proceed from all parts of his body: there was not the least ground, in fact, for this imagination. He was scrupulously clean in person, extremely courteous in manner, thoroughly rational in his conversation on every other subject, a shrewd and clever man of business; no one talking with him would for a moment have suspected him of entertaining such extraordinary fancies. Nevertheless, his life was made miserable by them; he would not go into society, but took solitary rambles in the country, where he might meet as few persons as possible; in his own house he slept for the first part of the night on the ground-floor, mounting up higher at a later period of the night; and this he did to prevent the bad odors from becoming too concentrated in one room. He believed that the people in the next house were irritated and offended by the emanations, for he often heard them moving about and coughing; and, when he passed a cab-stand in the street, he noticed that even the horses became restless and fidgeted. He used to hang his clothes out of the window at night that they might get pure, until his housekeeper put a stop to the practice by telling him that the exhibition of them would excite the notice and comment of his neighbors. All the while he was conducting his business with propriety and success; his own partners had no suspicion of his condi-

tion. Knowing this, I asked him how it was that no one of the many persons whom he met daily in business had ever complained of any bad smell, and the answer he made was that they were all too polite to do so, but he could see that they were affected nevertheless, as they sometimes put their handkerchiefs to their noses—no doubt for a quite innocent purpose.

Another gentleman was the victim of a very common hallucination: he was much afflicted by voices, which were continually speaking to him at all times and all places—in the quietude of his room and in the crowded streets, by night and by day. He had come to the conclusion that they must be the voices of evil spirits in the air which tormented him. They knew his thoughts, and replied to them before he had himself conceived them; the remarks which they made were always annoying, often threatening and abusive, and sometimes most offensive and distressing, and they disturbed him so much at night that he got very little sleep. He had been driven to the expedient of buying a musical-box, which he placed under his pillow when he went to bed. The noise of the music drowned the noise of the tormenting voices, and enabled him to get to sleep; but, as he said, the measure was not entirely satisfactory, because when the box had played out its tunes, it stopped, and he was obliged to wind it up again. It was impossible to persuade this gentleman, sensible as he seemed in other respects, that the voices had no real existence, and that they were due to the disordered state of his nervous system. After listening attentively to my arguments, he went away sorrowful, feeling that I had no help for him. I may remark, by-the-way, that auditory hallucinations of this kind are apt to occur in prisoners who are subjected to long periods of solitary confinement in their cells: they have no mental resources to fall back upon, and their brooding thoughts, not being distracted by the conversation of others, nor having their usual outlet in their own conversation, become audible by them as actual voices.

I might relate many more examples, but these will suffice. Each sense may of course be affected, and sight stands next to hearing in its liability to suffer. In *delirium tremens*, hallucinations of sight are characteristic features; the patient commonly sees reptiles and vermin in his room, serpents crawling over the floor, rats and mice running over his bed, and pushes them away in a state of restless agitation. In some forms of insanity, the sufferer mistakes persons, believing entire strangers to be near friends or relations; or, again, he may see a person, whom he imagines to be his persecutor, escape from the house, when there was really no such person, and buy a revolver, to be ready for him when next he comes prowling about; and in one form of the deepest melancholy, which is known as *melancholia attonita*, he has sometimes terrible hallucinations—sees, probably, a deep abyss of roaring flames or a vast sea of blood immediately in front of him, and will not make the least movement, lest he should be precipitated headlong

into it. There can be no doubt of the mental disorder of persons who suffer in this way, but it must not be supposed that hallucinations of sight do not occur to persons who are free from mental disorder. I cannot help thinking that they furnish the explanation of the firm belief in ghosts and apparitions which has prevailed among all nations and in all times. A belief so universal must have some deep foundation in the facts of Nature or in the constitution of man. One may freely admit that persons have seen apparitions and have heard voices which they thought to be supernatural; but, inasmuch as seeing is one thing, and the interpretation thereof quite another thing, it may be right to conclude that they were nothing more than hallucinations, and that the reason why no ghosts are seen now, when people pass through churchyards on dark nights, as our forefathers saw them, is that ghosts are not believed in nowadays, while we have gained a knowledge of the nature of hallucinations, and of the frequency of their occurrence, which our forefathers had not.

One does not fail to notice, when proper attention is given to the subject, a fact which is full of meaning, viz., that the apparitions which have been seen at different ages were in harmony with the dominant ideas or beliefs of the age. It is not probable that any one could be found at the present day to affirm that he had seen an old woman riding through the air on a broomstick to a witches' meeting, because the belief in witchcraft is happily wellnigh extinct; but two or three hundred years ago, when it would have been thought something like blasphemy to doubt the being and doings of witches, persons of character and veracity might have been found to avouch it solemnly. In like manner, apparitions of Satan were not very uncommon in the middle ages to persons who, like Luther, were in earnest spiritual conflict with him; but there is no instance on record, so far as I know, of such an apparition having ever been seen by an ancient Greek or Roman. The Satan of the middle ages who gave Luther so much trouble had not then been invented. Spirits, ghosts, then, and all apparitions of the same kind, I was prepared to have pronounced unhesitatingly to have been hallucinations, which would be found on examination to reflect pretty fairly the prevailing ideas of the time concerning the supernatural; but it occurred to me that it might be prudent, before doing that, to consult the article on apparitions in the latest edition of the "Encyclopædia Britannica," lest perchance I should be outrunning current authority; and I have there discovered, to my no small surprise, that it is still an open question whether invisible inhabitants of the unknown world did not take human or other shapes and become visible to men. The writer of the article plainly inclines to the opinion that they do, and that there is more in the matter than science has yet dreamed of. So also think the spiritualists.

I now go on to consider the mode of production of hallucinations. At the first blush there might seem to be a great gap between such

false perceptions of the senses as I have given examples of and the faithfully-serving senses of a person who is in good health of mind and body. But here, as elsewhere, in Nature we find, when we look closely into the matter, that there is no break; we may be pretty sure, perhaps, that, when we say of any phenomenon, however strange, that it is singular and quite unlike anything else in the world, we are mistaken, and that we shall not fail to discover other things like it if we search intelligently. Certainly we can trace gradational states between the most extreme hallucinations and such temporary disorders of the senses as healthy persons often have. Let any one stoop down with his head hanging low for a minute, and when he raises it he will have, besides a feeling of giddiness, a sound of singing or of ringing in his ears, and may see a flash or two of light before his eyes; and there are some persons who, under such circumstances, see actual figures for the moment. These sensations are hallucinations; there is no light, nor sound, nor figure, outside to cause them; they are owing to the stimulation of their respective nerve-centres by a congestion of blood in the brain, which has been produced by the hanging down of the head. Here, then, we have hallucinations that are consistent with the best health; they are due to temporary causes of disturbance of the circulation, and disappear as they disappear. Going a step further, we may watch at the beginning of a fever how gradually the hallucinations take hold of the mind, until their true nature is not recognized. At first the fever-patient is quite aware of his actual surroundings, knowing the persons and objects about him, and when strange faces seem to appear among the familiar faces, as they do, he knows that they are not real, and will talk of them as visions; perhaps they occur at first only when his eyes are shut, or when the room is dark, and vanish directly he opens his eyes or the room is lit up. After a while they come more often, and whether his eyes are shut or not; he becomes uncertain whether they are real or not, assenting when he is told that they are phantoms, but falling back immediately into doubt and uncertainty. At last they get entire mastery of him, he cannot distinguish in the least between them and real figures, discourses with them as if they were real—is wildly delirious.

If the nature of the process by which we perceive and know an external object be considered, it will be seen that it is much easier to have a false perception than might appear at first sight. When we look at any familiar object—say a cat or a dog—we seem to see at once its shape, its size, its smoothness of coat, and the other qualities by which we know it to be a cat or a dog, but we don't actually see anything of the kind. The proof is that, if a person blind from his birth, who knew the cat and dog perfectly well by touch, were to obtain sight by means of a surgical operation when he was thirty years old, he would not know by sight alone either cat or dog, or be able to tell which was which. But, if he were permitted to touch the animals,

ne would recognize them instantly, and ever afterward the impression which they produce on sight would be associated with the impression which they produce on touch, and he would know them when he saw them. That is the way in which the perception of a particular object is formed—by the association of all the sensations which it is adapted to excite in our different senses, their combination in what we call an idea. For example, in the idea of an orange are combined the sensations which we get by tasting it, by touching it, by smelling it, by looking at it, by handling it, each sensation having been acquired by its particular sense in the course of an education which has been going on ever since we were born; when we have got them in that way, they combine to form the *idea* of the orange; and it is by virtue of this idea, which has been formed and registered in the mind, that we are able to think of an orange, that is, to form a mental image of it, when it is not present to any sense, and to recognize it instantly when it is. It is plain, then, how large a part, by virtue of its past experience, the mind contributes to each perception; when we look at an orange it tacitly supplies to the impression which it makes on sight all the information about it which we have got at different times by our other senses, and which sight does not in the least give us; the visual impression is no more in truth than a sign to which experience has taught us to give its proper meaning, just as the written or spoken word in any language is a sign which is meaningless until we have been taught what to mean by it. So true it is that the eye only sees what it brings the faculty of seeing, and that many persons have eyes, yet see not.

This being so, it is clear that the idea in the mind will very much affect the perception, and that if any one goes to look at something, or to taste something, or to feel something, with a strongly-preconceived idea of what it is, he will be likely, if it is not what he thinks it, to have a mistaken perception—to see, or feel, or touch, what he thinks it is, not what it really is. This is, indeed, one of the most common causes of erroneous observation, and one which the scientific observer knows well he must always vigilantly guard against. If a man has a foregone conclusion of what he will see, it is not safe to trust his observation implicitly, either in science or in common life. We witness the most striking examples of this dominion of the idea over sense in persons who have been put into the so-called mesmeric state. The operator gives them simple water to taste, telling them at the same time that it is some nauseating and bitter mixture, and they spit it out with grimaces of disgust when they attempt to drink it; when he tells them what he offers them is sweet and pleasant, though it is as bitter as wormwood, they smack their lips as if they had tasted something remarkably good; if assured that a swarm of bees is buzzing about them, they are in the greatest trepidation, and go through violent antics to beat them off. Their senses are dominated by the idea suggested, and they are very much in the position of an insane

person who believes that he tastes poison in his food when he imagines that some one wishes to poison him, or sees an enemy lurking about his premises when he believes himself to be the victim of persecution.

Here, then, we are brought to one efficient cause of hallucinations —namely, a vividly-conceived idea which is so intense that it appears to be an actual perception, a mental image so vivid that it becomes a visual image. Everybody knows that the idea or imagination of a sensation will sometimes cause a person to feel the sensation; the mention or the sight of certain little insects which inhabit the bodies of uncleanly persons seldom fails to make the skin itch uncomfortably. John Hunter said of himself, "I am confident that I can fix my attention to any part until I have a sensation in that part." Sir Isaac Newton could call up a spectrum of the sun when he was in the dark, by intense direction of his mind to the idea of it, "as when a man looks earnestly to see a thing which is difficult to be seen." Dickens used to allege that he sometimes heard the characters of his novels actually speak to him; and a great French novelist declared that, when he wrote the description of the poisoning of one of his characters, he had the taste of arsenic so distinctly in his mouth that he was himself poisoned, had a severe attack of indigestion, and vomited all his dinner—a most pregnant proof of the power of imagination over sense, because arsenic has scarcely an appreciable taste beyond being sweetish! Artists sometimes have, in an intense form, the faculty of such vivid mental representation as to become mental presentation. It was very notable in that extraordinary genius, William Blake, poet and painter, who used constantly to see his conceptions as actual images or visions. "You have only," he said, "to work up imagination to the state of vision, and the thing is done." The power is, without doubt, consistent with perfect sanity of mind, although it may be doubtful whether a person who thought it right for himself and his wife to imitate the naked innocence of paradise in the back-garden of a Lambeth house, as Blake did, was quite sane; but too frequent exercise of the power is full of peril to the mind's stability. A person may call up images in this way, and they will come, but he may not be able to dismiss them, and they may haunt him when he would gladly be rid of them. He is like the sorcerer who has called spirits from the vasty deep, and has forgotten the spell by which to lay them again. Dr. Wigan tells of a skillful painter whom he knew, who assured him that he had once painted three hundred portraits in one year. The secret of his rapidity and success was, that he required but one sitting and painted with wonderful facility. "When a sitter came," he said, "I looked at him attentively for half an hour, sketching from time to time on the canvas. I wanted no more; I put away my canvas and took another sitter. When I wished to resume my first portrait, I took the man and set him in the chair, where I saw him as distinctly as if he had

been before me in his own proper person—I may almost say more vividly. I looked from time to time at the imaginary figure, then worked with my pencil, then referred to the countenance, and so on, just as I should have done had the sitter been there. When I looked at the chair I saw the man. . . . Gradually I began to lose the distinction between the imaginary figure and the real person, and sometimes disputed with sitters that they had been with me the day before. At last I was sure of it, and then—and then—all is confusion. I suppose they took the alarm. I recollect nothing more. I lost my senses—was thirty years in an asylum. The whole period, except the last six months of my confinement, is a dead blank in my memory."

Or, if the person does not go out of his mind, he may be so distressed by the persistence of the apparition which he has created as to fall into melancholy and despair, and even to commit suicide.

"I knew," says the same author, "a very intelligent and amiable man, who had the power of thus placing before his own eyes *himself*, and often laughed heartily at his double, who always seemed to laugh in turn. This was long a subject of amusement and joke; but the ultimate result was lamentable. He became gradually convinced that he was haunted by himself. This other self would argue with him pertinaciously, and, to his great mortification, sometimes refute him, which, as he was very proud of his logical powers, humiliated him exceedingly. He was eccentric, but was never placed in confinement, or subjected to the slightest restraint. At length, worn out by the annoyance, he deliberately resolved not to enter on another year of existence—paid all his debts, wrapped up in separate papers the amount of the weekly demands, waited, pistol in hand, the night of the 31st of December, and as the clock struck twelve fired it into his mouth."

Were illustrations needed of the production of hallucination by the intensity of the conception, I might take them from Shakespeare, who has given many instances of these "coinages of the brain" which, he says truly, ecstasy is very cunning in. Hamlet, perturbed by the apparition of his father's ghost, whose commands he was neglecting, bends his eyes on vacancy and holds discourse with the incorporeal air. A dagger, sensible to sight but not to feeling, points Macbeth the way to the bed where lay Duncan whom he was about treacherously to stab; he attempts to clutch it, exclaiming justly when he grasps nothing:

> ". . . . There's no such thing:
> It is the bloody business which informs
> Thus to mine eyes."

In the well-known passage in which he compares the imaginations of the lunatic, the lover, and the poet, Shakespeare sets forth the very manner of the production of hallucinations, and illustrates the gradations of the process:

"The lunatic, the lover, and the poet,
Are of imagination all compact:
One sees more devils than vast hell can hold;
That is the madman: the lover, all as frantic,
Sees Helen's beauty in a brow of Egypt:
The poet's eye, in a fine frenzy rolling,
Doth glance from heaven to earth, from earth to heaven;
And, as imagination bodies forth
The forms of things unknown, the poet's pen
Turns them to shapes, and gives to airy nothings
A local habitation and a name."

Or I might adduce the case of the great Protestant Reformer, Luther, who is said—I know not how truly—to have thrown his inkstand at the devil on one occasion; at any rate the mark of the ink is still shown on the wall of the chamber which Luther occupied. True or not, there is nothing improbable in the story; for Luther, though endowed with great sagacity and extraordinary intellectual energy, entertained the common notions of the personality and the doings of the devil which were current among the people of his age. He pictured him very much as a Saxon peasant pictured him. It was the devil, he believed, who caused a great storm, and he declared that idiots, the blind, the lame, and the dumb, were persons in whom devils had established themselves, and that physicians who tried to cure their infirmities as though they proceeded from natural causes were ignorant blockheads who knew nothing of the power of the demon. He speaks of the devil coming into his cell and making a great noise behind the stove, and of his hearing him walking in the cloister above his cell in the night; "but as I knew it was the devil," he says, "I paid no attention to him, and went to sleep."

This, then, is one way in which hallucination is produced—by the downward action of idea upon sense. My illustrations of this mode of production have been taken from sane minds, but the hallucinations of the insane are oftentimes generated in the same way. A person of shy, suspicious, and reserved nature, who imagines that people are thinking or speaking ill of him or going out of their way to do him harm, nurses his habit of moody suspicion until it grows to be a delusion that he is the victim of a conspiracy; he then sees evidence of it in the innocent gestures and words of friends with whom he holds intercourse, of servants who wait upon him, and of persons who pass him in the streets; these he misinterprets entirely, seeing in them secret signs, mysterious threats, criminal accusations. It may be pointed out to him that the words and gestures were perfectly natural and innocent, and that no one but himself can perceive the least offense in them; his belief is not touched by the demonstration, for his senses are enslaved by the dominant idea, and work only in its service. Sometimes an insane patient, who tastes poison in his food

and refuses it when it is given to him by one attendant whom he suspects of poisoning him, will take the same food from another attendant, of whom he has no suspicion, without tasting any poison—a proof how much the morbid idea perverts his taste. There is a form of insanity, known as general paralysis, which is marked by an extraordinary feeling of elation and by the most extravagant delusions of wealth or grandeur, and the patient who labors under it often picks up pebbles, pieces of broken glass, and the like, which he hoards as priceless jewels: there is another form of insanity known as melancholia, which is marked by an opposite feeling of profound mental depression and corresponding gloomy delusions, and the patient who labors under its worst form sometimes sees devils in those who minister to him, hears jeers in their consoling words, and imagines torments in their anxious attentions. In each case the hallucinations reflect the dominant morbid feelings and ideas.

A second way in which hallucinations appear to originate is directly in the organ of sense or in its sensory ganglion, which for present purposes I may consider as one. Stimulation of the organ or of its ganglion will undoubtedly give rise to hallucination: a blow on the eye makes a person see sparks of fire or flashes of light, a blow on the ear makes his ears ring; in fact, any organ of sense, when irritated either by a direct stimulus to its nerve-centre, or by a perverted state of the blood which circulates through it, will have the same sensation aroused in it, no matter what the stimulus, as is produced by its natural stimulus. We can irritate the sensory ganglion directly by introducing certain poisonous substances into the blood, and so occasion hallucinations: for example, when a person is poisoned with belladonna (deadly nightshade) he smiles and stares and grasps at imaginary objects which he sees before him, and is delirious. Other drugs will produce similar effects. A French physiologist has made a great many experiments in poisoning dogs with alcohol by injecting it into their veins, and he has found that he can arouse in them very vivid hallucinations: the dog will start up, perhaps, with savage glare, stare at the blank wall, bark furiously, and seem to rush into a furious fight with an imaginary dog; after a time it ceases to fight, looks in the direction of its imaginary adversary, growling once or twice, and settles down quietly.

The hallucinations which occur in fevers and in some other bodily diseases evidently proceed directly from disorder of the sensory centres, and not from the action of morbid idea upon sense; for we have seen that before they are fixed the intellect struggles against them successfully and holds them in check. A well-known and instructive instance of hallucinations, due to bodily causes, and which did not affect the judgment, is that of Nicolai, a bookseller of Berlin, who, being a person of great intelligence, observed his state carefully and has given an interesting account of it. He had been exposed to a succession of severe trials which had greatly affected him, when, after an incident

which particularly agitated and distressed him, he suddenly saw at the distance of ten paces a figure—the standing figure of a deceased person. He asked his wife if she could not see it, but she, as she saw nothing, was alarmed and sent for a physician. When he went into another room it followed him. After troubling him for a day it disappeared, but was followed by several other distinct figures; some of them the figures of persons he knew, but most of them of persons he did not know. "After I had recovered," he says, "from the first impression of terror, I never felt myself particularly agitated by these apparitions, as I considered them to be what they really were—the extraordinary consequences of indisposition; on the contrary, I endeavored as much as possible to preserve my composure of mind, that I might remain distinctly conscious of what passed within me." He could trace no connection between the figures and his thoughts, nor could he call up at his own pleasure the phantoms of acquaintances which he tried to call up by vivid imagination of them; however accurately and intensely he pictured their figures to his mind, he never once succeeded in his desire to see them *externally*, although the figures of these very persons would often present themselves involuntarily. He saw the figures when alone and in company, in the daytime and in the night; when he shut his eyes they sometimes disappeared, sometimes not; they were as distinct as if they were real beings, but he had no trouble in distinguishing them from real figures. After four weeks they began to speak, sometimes to one another, but most often to him: their speeches were short and not disagreeable. Being recommended to lose some blood, he consented. During the operation the room swarmed with human figures, but a few hours afterward they moved more slowly, became gradually paler, and finally vanished. This example proves very clearly that a person may be haunted with apparitions, and yet observe them and reason about their nature as sanely as any indifferent outsider could do. It illustrates very well, too, the second mode of origin; for it is reasonable to suppose that they were produced by congestion of blood in the brain acting upon the sensory centres, and that they were dissipated by the removal of the congestion by bloodletting. This is the more probable, as cases have been recorded in which the suppression of an habitual discharge of blood from the body has been followed by hallucinations, and others again in which hallucinations have been cured by the abstraction of blood.

Exhaustion of the nerve-centres themselves by excessive fatigue, mental and bodily, or by starvation, or by disease, will cause a person to see visions sometimes. I may call to mind the well-known case of Brutus, who, as he sat alone at night in his tent before the decisive battle of Philippi, rapt in meditation, saw on raising his eyes a monstrous and horrible spectre standing silently by his side. "Who art thou?" he asked. The spectre answered: "I am thy evil genius, Brutus. Thou wilt see me at Philippi." He replied, "I will meet thee

there." The religious ascetic who withdrew himself from the society of men to some solitary place in the desert or to some cave in the hills, there passing his lonely life in prayer and meditation, and mortifying his body with long fastings and frequent scourgings, brought himself to such a state of irritable exhaustion that he commonly saw, according to his mood of feeling, either visions of angels and saints who consoled him in his sufferings, or visions of devils who tempted and tormented him.[1] The shipwrecked sailor, when delirious from the exhaustion produced by want of food and drink, sometimes has attractive visions of green fields and pleasant streams, and cannot be prevented from throwing himself overboard in the mad desire to reach them. The dying person, in the last stage of exhaustion from a wasting disease, has had his deathbed visions of joy or of horror; the good man, whose mind was at rest, has been comforted by visions of heaven; the wicked man, whose troubled conscience would not let him die in peace, has been terrified with spectres of horror—the murderer, perhaps, by the accusing apparition of his victim. These were thought at one time to be supernatural visitations; they are known now to be for the most part hallucinations, such as occur in the last stage of flickering life, when, to use Shakespeare's words—

> "His brain doth, by the idle comments that it makes,
> Foretell the ending of mortality."[2]

[1] This is a Mohammedan receipt for summoning spirits:

"Fast seven days in a lonely place, and take incense with you, such as benzoin, aloes-wood, mastic, and odoriferous wood from Soudan, and read the chapter 1001 times (from the Koran) in the seven days—a certain number of readings, namely, for every one of the five daily prayers. That is the secret, and you will see indescribable wonders; drums will be beaten beside you, and flags hoisted over your head, and you will see spirits full of light and of beautiful and benign aspect."—"Upper Egypt; its People and Products," by Dr. Klunzinger, p. 386.

An acquaintance of his, who had undergone the course of self-mortification, said that he really saw all kinds of horrible forms in his magic circle, *but he saw them also when his eyes were shut.* At last he got quite terrified and left the place.

[2] In the second part of "Henry VI.," Shakespeare gives an instance of a fearful death-bed hallucination, when Cardinal Beaufort is at the point of death:

> "*King.* How fares my lord? Speak, Beaufort, to thy sovereign.
> *Cardinal.* If thou be'st death, I'll give thee England's treasure,
> Enough to purchase such another island,
> So thou wilt let me live, and feel no pain.
> *King.* Ah, what a sign it is of evil life,
> Where death's approach is seen so terrible!
> *Warwick.* Beaufort, it is thy sovereign speaks to thee.
> *Car.* Bring me unto the trial when you will.
> Died he not in his bed? where should he die?
> Can I make men live, whether they will or no?
> Oh, torture me no more! I will confess.
> Alive again? then show me where he is:
> I'll give a thousand pounds to look upon him.
> He hath no eyes, the dust hath blinded them.
> Comb down his hair; look, look, it stands upright,
> Like lime-twigs set to catch my winged soul.
> Give me some drink; and bid the apothecary
> Bring the strong poison that I bought of him."

I cannot, of course, enumerate all the bodily conditions in which hallucinations appear, but there is one more which I shall mention particularly, because it has been the foundation of a prophetic or apostolic mission. It is not at all uncommon for a vivid hallucination of one or other of the senses, of hearing, of sight, of smell, of touch, of muscular sensibility, to precede immediately the unconsciousness of an epileptic fit. It may be a command or threat uttered in a distinct voice, or the figure of a person clearly seen, or a feeling of sinking into the ground or of rising into the air; and a common visual hallucination on such occasions is a flash, a halo, or a flood of bright or colored light, which makes a strong impression before the person falls unconscious. When he comes to himself he remembers it vividly, and believes, perhaps, that it was a vision of an angel of light or of the Holy Ghost. There can be no doubt that angelic apparitions and heavenly visions have sometimes had this origin. Proceeding from the sensory centre, not from the higher centres of thought, they are calculated to produce the stronger impression of their miraculous nature; for, if the person knows that he was not thinking of anything of the kind when the vision occurred, he will naturally be the more startled and affected by it. I might give many striking examples in proof of what I say, but I will content myself with an ordinary and comparatively recent one. Two or three years ago a laborer in the Chatham dock-yard, who was epileptic, and had once been in an asylum for insanity, suddenly split the skull of a fellow-laborer near him with an adze. There was no apparent motive for the deed, for the men were not on bad terms. He was, of course, tried for murder, but was acquitted by the jury on the ground of insanity, in accordance with the medical evidence, but directly in the teeth of a strong charge of the judge, and much to the disappointment of certain newspapers, whose editorial feelings are sadly harrowed whenever an insane person escapes from the gallows. He is now in the criminal asylum at Broadmoor, and he has told the medical officers there —what was not known at the trial—that some years before the murder he had received the Holy Ghost; that it came to him like a flash of light, and that his own eyes had been taken out, and other eyes, like balls of fire, substituted for them. A characteristic epileptic hallucination! Let us suppose that this man had undertaken some prophetic mission, as epileptics have done, and had put into it all the energy of his epileptic temperament, he would have declared with perfect sincerity, so far as he was concerned, that the Holy Ghost appeared to him in a vision as an exceeding bright light, and, behold! his own eyes were taken out and balls of fire were in their places.

Some persons maintain that the earliest visions of Mohammed, who, like Cæsar, was epileptic, were of this kind, and that his change of character and the assumption of his prophetic mission followed an epileptic vision. Tradition tells us that he was walking in solitude in the lonely defiles and valleys near Mecca, when every stone and tree greeted

him with the words, "Hail to thee, O messenger of God!" He looked round to the right and to the left, but discovered nothing but stones and trees. Soon after this the angel Gabriel appeared to him in a vision on the mountain Hira, and announced to him the message of God. The origin of the hallucination seems to have been in this wise: While walking in the valley meditating in solitude on the degrading idolatry of the people, and girding himself to the resolution to undertake a great work of reform which might well seem beyond his strength, and make him pause, the intense thoughts of his mental agony were suddenly heard by him as a real voice, where there was no voice; and the vision which he saw when he next fell into an epileptic trance was deemed to be the apparition of the angel Gabriel.

If this be so, and much more if all the apparitions and visions which mankind have seen at different times were really hallucinations, it is startling to reflect what a mighty influence illusions have had on the course of human history. One is almost driven to ask in despair whether all in the world is not illusion, whether "all that we see and seem is not a dream within a dream." But there are countervailing considerations which may abate alarm. If a great work in the world has been done in consequence of a vision which was not, as it was believed to be, a supernatural revelation, but an hallucination produced in accordance with natural laws, the work done, were it good or bad, was none the less real. And inasmuch as the hallucination, whatever its character, is in accordance with the habit of thought and feeling of the person to whom it occurs, and is interpreted, if it be not actually generated, by his manner of thinking, we may put it out of sight as a thing of secondary importance, as an incidental expression, so to speak, of the earnest belief, and fix our minds on this belief as the primary and real agent in the production of the effect. Had Mohammed never seen the angel Gabriel, it is probable that the great mission which he accomplished—the overthrow of idolatry and polytheism and the welding of scattered tribes into a powerful nation—would have been accomplished either by him or by some other prophet, who would have risen up to do what the world had at heart at that time. Had any one else who had not Mohammed's great powers of mind, and who had not prepared himself, as he had done, by many silent hours of meditation and prayer, to take up the reformer's cross, seen the angel Gabriel or any number of angels, he would not have done the mighty work. Who can doubt that the mission of Mohammed was the message of God to the people at that time, as who can doubt that the thunder of the Russian cannon has been the awful message of God to the Mohammedan Turks of this time?

So much, then, for the nature of hallucinations and their principal modes of origin. Although they sometimes originate primarily in the sensory centres, and sometimes primarily in the higher centres of thought, it is very probable that, in many instances, they have a

mixed origin. It can hardly be otherwise, seeing how intimate is the structural and functional connection between the nerve-centres of thought and sense, and how likely so closely connected nerve-centres are to sympathize in suffering when the one or the other is disordered.

No one pretends that a person who, laboring under hallucinations, knows their true nature, as Nicolai did, is insane; but it is often said that he has passed the limits of sanity and must be accounted insane when he does not recognize their real nature, and believes in them and acts upon them. But the examples which I have given prove this to be too absolute a statement. I should be very loath to say that either Mohammed or Luther was mad. When the hallucination is the consistent expression of an earnest and coherent belief, which is not itself the product of insanity, it is no proof of insanity, although it may indicate a somewhat unstable state of the brain, and warn a prudent man to temper the ardor of his belief. When, however, a person has hallucinations that are utterly inconsistent with the observation and common-sense of the rest of mankind; when he cannot correct the mistakes of one sense by the evidence of another, although every opportunity is afforded him to do so; when he believes in them in spite of confuting evidence, and when he suffers them to govern his conduct, then he must certainly be accounted insane: he is so much out of harmony of thought and feeling with his kind that we cannot divine his motives or reckon upon his conduct, and are compelled to put him under restraint. Persons of this class are apt to be troublesome and even dangerous; believing that they are pursued by a conspiracy, hearing the threatening voices of their persecutors wherever they go, seeing proofs everywhere of their evil machinations, smelling poisonous fumes, feeling the torture inflicted by concealed galvanic wires, they endeavor to protect themselves by all sorts of devices—appeal to the magistrates and the police for assistance, become public nuisances in courts of justice, are, perhaps, driven at last, either from despair of getting redress, or by the fury of the moment, to attack some one whom they believe to be an agent in the persecution which they are undergoing. Some of them hear voices commanding them peremptorily to do some act or other—it may be to kill themselves or others—and they are not unlikely in the end to obey the mysterious commands which they receive.

Having said so much concerning the causation and character of hallucinations, I ought, perhaps, before concluding, to say something about the means of getting rid of them. Unfortunately, it is very little that I can say, for, when once they have taken firm hold of a person, they are seldom got rid of. When they occur during an acute case of insanity, where there is much mental excitement, they certainly often disappear as the excitement passes off, or soon afterward, just as they disappear when the delirium of fever subsides; but, when they have become chronic, they hold their ground in defiance of every

kind of assault upon them. Over and over again the experiment has been tried of proving to the hallucinated patient in every possible way, and by every imaginable device, that his perceptions are false, but in vain:

> ". . . . You may as well
> Forbid the sea for to obey the moon
> As or by oath or counsel shake
> The fabric of his folly, whose foundation is
> Piled upon his faith, and will continue
> The standing of his body."

There is more to be done to prevent hallucinations, I think, than to cure them; that is to say, by prudent care of the body and wise culture of the mind. Looking to their mode of origin, it is obviously of the first importance, trite maxim as it may seem, to keep the body in good health; for not only will bodily disorder directly occasion hallucinations by disturbance of the sensory centres, but by its depressing influence on the entire nervous system it hinders sound, and predisposes to unsound, thought and feeling. Every one knows how hard a matter it is to perceive accurately, to feel calmly, and to think clearly, when the liver is out of order; there is then a good foundation for hallucination. It has so long been the habit to exalt the mind as the noble, spiritual, and immortal part of man, at the expense of the body, as the vile, material, and mortal part, that, while it is not thought at all strange that every possible care and attention should be given to mental cultivation, a person who should give the same sort of careful attention to his body would be thought somewhat meanly of. And yet I am sure that a wise man, who would ease best the burden of life, cannot do better than watchfully to keep undefiled and holy—that is, healthy—the noble temple of his body. Is it not a glaring inconsistency that men should pretend to fall into ecstasies of admiration of the temples which they have built with their own hands, and to claim reverence for their ruins, and, at the same time, should have no reverence for, or should actually speak contemptuously of, that most complex, ingenious, and admirable structure which the human body is? However, if they really neglect it, it is secure of its revenge; no one will come to much by his most strenuous mental exercises, except upon the basis of a good organization—for a sound body is assuredly the foundation of a sound mind.

In respect of the mental cultivation to be adopted, in order to guard against hallucination, I can now only briefly and vaguely enforce one important principle—namely, the closest, most exact, and sincere converse with nature, physical and human. Habitual contact with realities in thought and deed is a strong defense against illusions of all sorts. We must strive to make our observation of men and things so exact and true, must so inform our minds with true perceptions, that there shall be no room for false perceptions. Calling to mind what has been said concerning the nature of perception—how the most complete

and accurate perception of an object is gained by bringing it into all its possible relations with our different senses, and so receiving into the idea of it all the impressions which it was fitted to produce upon them —it will appear plainly how necessary to true perception, and to sound thought, which is founded on true perception, and to wise conduct, which is founded on sound thought, are thoroughness and sincerity of observation. So to observe Nature as to learn her laws and to obey them, is to observe the commandments of the Lord to do them. Speculative meditations and solitary broodings are the fruitful nurse of delusions and illusions. By faithfully intending the mind to the realities of Nature, as Bacon has it, and by living and working among men in a healthy, sympathetic way, exaggeration of a particular line of thought or feeling is prevented, and the balance of the faculties best preserved. Notably the best rules for the conduct of life are the fruits of the best observations of men and things; the achievements of science are no more than the organized gains—orderly and methodically arranged—of an exact and systematic observation of the various departments of Nature; the noblest products of the arts are Nature ennobled through human means, the art itself being Nature. There are not two worlds—a world of Nature and a world of human nature—standing over against one another in a sort of antagonism, but one world of Nature, in the orderly evolution of which human nature has its subordinate part. Delusions and hallucinations may be described as discordant notes in the grand harmony. It should, then, be every man's steadfast aim, as a part of Nature, his patient work, to cultivate such entire sincerity of relations with it, so to think, feel, and act, always in intimate unison with it, to be so completely one with it in life, that when the summons comes to surrender his mortal part to absorption into it, he does so, not fearfully, as to an enemy who has vanquished him, but trustfully, as to a mother who, when the day's task is done, bids him lie down to sleep.—*Fortnightly Review.*

YELLOW FEVER.

By ROGER S. TRACY, M. D.

AN attack of yellow fever is generally quite sudden, though in some cases there are slight premonitory symptoms, such as loss of appetite, general uneasiness, headache, or costiveness. It is commonly ushered in by chilliness, alternating with flushes of heat, or the person may be overcome with languor and extreme debility, while at his usual occupation. These feelings are soon followed by fever, and the bodily temperature rises rapidly, often reaching 102½° Fahr. in a few hours, the normal temperature being 98.4°. The fever is accom-

panied by headache, generally located immediately over the eyes, or shooting through from temple to temple, and often very severe. But the headache is frequently trivial in comparison with the frightful pains in the loins, which make the patient writhe in agony. The pulse is generally full, strong, and rapid, beating from ninety to a hundred and twenty times a minute. The skin is hot and dry, the face flushed, the eyes bloodshot, brilliant, and watery, and the tongue covered with a creamy white fur, but with red, clean tip and edges. There is usually some uneasiness of the stomach from the first, and in from twelve to twenty-four hours this develops into nausea and a persistent sensitiveness, which will not allow anything to be retained. The pit of the stomach is very tender on pressure, and vomiting is almost incessant. With all this there is intense thirst, and iced drinks are exceedingly grateful to the patient. The bowels are at first generally costive, and sometimes obstinately so, but, as the disease progresses, they become loose. The patient is usually very much debilitated, but is uneasy and tosses about in bed, and occasionally will try to rise and walk about the room. In most cases there is some confusion of intellect, not amounting to delirium, and the face expresses the greatest anxiety and distress. The fever continues for two or three days, being most severe in the evening, the temperature often reaching 104° or 105°, and, according to La Roche, in malignant cases, even 110°. Then the fever subsides, never to return, and the temperature within twelve hours may become nearly normal. The other symptoms mostly disappear, and the organs resume their natural functions. At this time, i. e., on the third or fourth day, the yellow discoloration of the skin appears upon the face and thence extends over the body. If the attack is mild, recovery is now rapid. In the vast majority of cases, however, this lull in the symptoms is deceitful, and lasts only from a few hours to a day, when the gravest stage of the disease sets in. The pulse soon becomes small and thready, beating only thirty or forty to the minute, and the heart often works vigorously after the pulse can no longer be felt at the wrist. The nausea and vomiting return and become constant, the respiration is often embarrassed, the tongue becomes dry and brown, the skin is cool and dry, there is often a distressing hiccough, and the thirst is insatiable. The mind is often clear, but singularly apathetic, or there may be delirium or stupor. The disorganization of the blood and the tissues has now gone so far that the small vessels of the mucous membranes no longer retain their contents, and blood oozes into the stomach. This produces intense nausea, and the blood is vomited up, changed in color by the acids with which it is mingled. This forms the dreadful "black-vomit," and varies in hue from brown to almost jet black, generally appearing like coffee-grounds floating in a thin, watery fluid. The urine, which becomes scanty early in the disease, may now be entirely suppressed, or, if excreted at all, is black and bloody. The discoloration of the skin increases, until the body is of a dusky brown,

livid or mahogany color, and there are frequent hæmorrhages from the mouth, nose, eyes, or even under the skin, forming livid spots and blotches. The body now exhales a cadaverous odor, the tendons of the wrist twitch convulsively, hiccough is constant, the features are pinched and ghastly, cold sweats come on, and the patient passes away in convulsions or coma, though occasionally he retains his intellectual faculties unimpaired to the last.

Patients may recover in either of the three stages above described. A favorable termination is indicated by a gradual amelioration of all the symptoms, or sometimes by profuse perspiration, sudden cessation of nausea, rapid return of the pulse to its natural fullness and strength, or other marked event, which seems to indicate a crisis in the disease.

The symptoms of yellow fever vary exceedingly at different times, in different localities, and in different persons. Sometimes a person is smitten with the disease as with apoplexy, falls into a profound collapse, and dies in a few hours. Others walk about the room, or even out in the street, and insist that they are perfectly well; or, if they acknowledge that anything is the matter with them, complain merely of weariness or debility. They often betray no symptom of the disease to the casual observer; but the physician will see an expression of dullness or listlessness in the face, and a wateriness of the eye, and will find the pulse feeble or even absent. The patient may even be talking, smoking, or reading, when black-vomit comes on, and he is speedily a corpse. To a non-professional person the exceeding variability of the symptoms cannot, perhaps, be better shown than by quoting a line or two from the work of La Loche, of 1,400 pages, on "Yellow Fever:" "The skin is hot, dry, harsh, and pungent, or it may be dry, unctuous, or perspiring, flabby, and cold. . . . The pulse becomes rapid, irregular, and depressed; or, more generally, it is natural in frequency, or even slower than in health." And this, of the *post-mortem* appearances, is a gem in its way: "The liver is usually of a light-yellow, nankeen, fresh-butter, straw, coffee-and-milk, gum-yellow, buff, gamboge, light-orange, or pistachio color; or it may be dark-yellow, brown, red, purple, bluish, slate, chocolate, or livid." Even the characteristic symptoms of yellow skin and black-vomit may occur in other diseases, and they may both be absent in yellow fever. These differences in the disease are largely due, in all probability, to individual idiosyncrasies, and to the simultaneous presence of other morbid processes. Thus, the present terrible epidemic at the South, from all we can learn, seems to be decidedly modified by the malarial atmosphere of that region, and presents so many of the features of the pernicious malarial fevers that some physicians (whether competent or not I do not know) decline to report their cases as yellow fever.

The disease lasts from three to nine days, and in severe cases recovery is apt to be very slow. Relapses are not common. The black-

vomit, indicating, as it does, a profound disorganization of the blood, is, in most cases, a fatal sign. Alvarenga states that, in the epidemic of 1857, at Lisbon, out of one hundred and seventy-eight cases of black vomit, forty recovered, but this is an isolated experience, and in this country, at least, such recoveries are rare. The mortality varies between five and seventy-five per cent. of those attacked.

The disease develops in from one to fourteen days after exposure. Those most liable to it are strangers or recent comers. Old residents enjoy a certain immunity, excepting in severe epidemics, and, even if they are attacked, the disease is generally mild. Women and children, old persons, and those of delicate constitutions, are usually less liable to it than robust, healthy men. This year the children are said to have suffered most. The negro natives are generally exempt, though it has been noticed that negroes who have left the South for the North, and have returned during an epidemic, do not possess this immunity. In the present epidemic, even the negroes seem to succumb in great numbers. It is a singular fact that persons exposed to offensive effluvia when working at their trade, as tanners, butchers, soap-boilers, and scavengers, are almost exempt from the disease, while those whose trade exposes them to great variations of temperature, as bakers and cooks, are extremely prone to it. Like small-pox, it may occur more than once in the same person, but, as a rule, those who have had it once are never attacked again.

All methods of treatment agree in the principal points. The bowels must be cleared at the start, and the patient kept perfectly quiet. The temperature is kept down by applications of cold water, and ice is applied to the head if symptoms of congestion of the brain appear. The excessive thirst is relieved by swallowing lumps of ice, and the nausea controlled to some extent by iced lemonade or champagne. In the West Indies, lemon-juice plays an important part in the treatment, and the old negro nurses rub it over the surface of the body. When the appetite revives, great caution has to be exercised, as a premature return to solid food may result fatally.

The first fully recorded outbreak of the disease was in the West Indies in 1647, and since then it has recurred at irregular intervals, and has gradually extended its range. Epidemics have occurred as far north as Quebec and as far south as Montevideo, as far west as Mexico and as far east as Algiers. It is endemic in the West Indies, Venezuela, New Granada, and Mexico, on the easterly coast of the United States as far north as Charleston, South Carolina, and on the northerly coast of Africa. To become epidemic, it requires a mean temperature of at least 72°, and Griesinger holds that the temperature must be as high as 80° for a considerable time before it can acquire a foothold, though West Indian physicians have seen the temperature fall suddenly just before an outbreak. If the temperature falls during an epidemic its severity abates, and at 32° it disappears entirely. It

rarely occurs inland, but follows water-courses and lines of ocean-travel, and so usually appears in commercial cities, and begins its march at the wharves. It is uncommon in elevated regions, and 2,500 feet is commonly regarded as its altitudinal limit, but it has been known to occur at Newcastle, Jamaica, at a height of 4,000 feet, and if the belief be true that ancient Mexico was visited by it under the name of *matlazahuatl*, then it has been epidemic at a height of between 7,000 and 8,000 feet above the sea.

There has been no severe epidemic of this disease in New York since 1822, but it breaks out on our Gulf and South Atlantic coasts at intervals, with no appearance of periodicity. It first appeared in New Orleans in 1796, and has often been epidemic there since. The most fatal epidemic was that of 1853, when the deaths were variously stated at from 8,000 to 10,000, or about eight times as many as have occurred there during the present summer, though the population was only half as large. It is the common impression that New Orleans was saved from the disease during its occupation by Federal troops in 1862–'65, because the city was put in such excellent sanitary condition; but Dr. Nott calls attention to the fact that there are often periods of exemption from the disease in all places visited by it, and that in New Orleans in 1859 there were only 91 deaths from yellow fever, in 1860 only fifteen, and in 1861 not a single one; while in 1863 Dr. Harris says there were nearly 100 cases of the disease, with two officially recorded deaths, and in 1864 more than 200, with 57 deaths.

Yellow fever occupies a singular position between the contagious and non-contagious diseases. The poison is not, like that of small-pox, directly communicable from a sick person to a well one; but, although the emanations of the sick are connected with the spread of the disease, they seem to require an appropriate nidus in which to germinate and develop. This nidus must be warm and moist, and there the germs, whatever they are, lie and grow, or, in some way develop until they are able to migrate. The germs are portable, and may be conveyed in baggage or merchandise (*fomites*) for hundreds or thousands of miles. If not so conveyed, its progress is very slow. In 1822 in New York, when it gained a foothold in Rector Street, it appeared to travel about forty feet a day until killed by the frost. It often leaves a house or a block intact, going around it and attacking those beyond, with no assignable reason. A thin board partition seems to have stopped it on Governor's Island in 1856, and an instance is related where it attacked the sailors in all the berths on one side of a ship before crossing to the other. Such apparent vagaries are, in the present state of our knowledge, inexplicable.

BIRD OR REPTILE—WHICH?

By HENRY O. FORBES.

TO most people it may appear not only easy enough to distinguish, but even a matter of some difficulty not to be able to identify, a bird from a reptile or from any other animal whatsoever. No one would hesitate for a moment to assign to the bird tribe, on seeing them even for the first time, forms differing from each other so much as the "wingless" apteryx of New Zealand and the strong-pinioned albatross; the marvelously tinted humming-bird and the raw-necked vulture; or the fleet ostrich and the stolid hornbill; for in each individual the eye at once perceives one character at least common to the whole assemblage which is wanting in all other groups. Yet the question to be discussed in this paper of bird or not-bird, and in particular of bird or reptile, is, as we shall see below, one not without serious difficulty.

In order to a more easy comprehension of the question, let us shortly, and with as few technicalities of expression as possible, pass in review the chief characters of the groups we have placed in apposition.

Birds may be characterized generally as feathered bipeds, whose mouth is modified into a longer or shorter beak incased in a horny sheath, sometimes serrated along the margin, but never presenting true teeth; whose fore-limbs assume the form of wings more or less developed, and having the hind-limbs supported on, at most, four toes, the innermost, however, in many birds being so imperfectly developed as not to reach the ground.

Every one who has handled a living bird knows that it is warm-blooded; and whoever, while not neglecting the "main chance," when dining on partridge or fowl, has nevertheless not been too absorbed to mark the prominent points that distinguished the skeletal remains of his feast from those of a hare, for instance, is aware that along the centre of the breastbone there runs a high crest for the attachment of the wing-muscles; that the collar-bones unite to form the bone of destiny with which he has been familiar from his youth as the "merry-thought;" that the haunch-bone, which incloses the bowels and gives attachment to the hind-limbs, differs from a higher quadruped's in being composed, not of two bones (each of which is in reality made up of three bones ossified together), one on each side articulating with yet separate from the spine, and touching each other in the median line beneath, but of these elements and several vertebræ in addition, consolidated into one, having the margins free and separated by a considerable space from each other below; and that instead of a tail, commonly so called, the rear of the spinal column is brought up by what is

known as the "ploughshare" bone formed by the union of several of its segments into a terminal mass for the support of the rudder-quills and of the oil-gland. Several very marked characteristics are to be seen in the hind-limb, to which, without entering deeply into osteological details, we may draw attention. Opening into the hollow shafts of the stronger bones—a character common to those of the wing and parts of the spine—there are to be found small pores, the air-passages by which the air-sacs, themselves extensions of the air-tubes of the lungs, are prolonged into the bones. In the skull also we find numerous air-cavities; these, however, are filled, not from the lung air-system, but from the nasal and ear chambers. No one who has examined the leg-bone, often called the "drumstick" (technically known as the tibia), of a common fowl, can have failed to observe the great ridge, or prominent crest, on the front of its upper extremity, or how easily the pulley-shaped articular surface of its lower end separates off from the shaft in the young bird, especially if the bone has been boiled or macerated for some time in water. This peculiarity vanishes when the fowl attains to its full growth; but till then the separation remains, as if to assert the right of the extremity to be considered, what in reality it is, a separate and distinct bone, the sole representative of a colony of ossicles (corresponding to the bones of the heel in the human foot) once existing in its grandsires at this spot, which for reasons of expediency has here coalesced with its long neighbor. On its outer side the leg-bone is always accompanied by a very slender bone, known as the fibula, attached only at its upper end, tapering gradually to a point about the middle of its fellow. Lastly, to the leg-bone immediately succeeds the hock-bone, the beautiful conformation of whose lower end into the resemblance of a triple pulley, for the articulation of the toes, is a mark by which we can unhesitatingly say that it belonged to a bird.

Bearing in mind these peculiarities, for whose detection no very deep scrutiny is required, which are but a few, yet sufficient for our present purpose, of the more striking characteristics to which the members of the Avian family more or less closely conform, we shall now for a little turn our attention to that other division of the animal kingdom with which we have in the title of this article contrasted the bird.

The reptiles are a wonderfully interesting group on account not only of the marvelous variety of their habits and modes of life, but also of their manifold diversity of form. Our country, in common with the rest of Northern Europe, can claim to be the habitat of but few examples of this tribe, whose home is under warmer latitudes; and consequently only limited opportunities present themselves to the European student for becoming acquainted with their habits and animated forms, unless he happens to live within reach of the menageries of the Zoölogical Societies of London, Berlin, Paris, or Amsterdam; those who are unfortunately distant from such interesting educational centres must

make their acquaintance in a mummified or skeletonized form in museums. It cannot but strike the visitor to any zoölogical collection where the vertebrated section is well represented that the cases devoted to the reptilian group contain forms so divergent as the tortoise and the lizard, the snake and the alligator. If, however, the eye be permitted to pass to the sections on either hand—on the one side, to the amphibious animals, such as the frogs and newts, and on the other, to the birds—it is impossible not to perceive that the contrast is very great. A careless or inexperienced classifier might, perchance, be tempted to relegate the lizard to a place among the amphibia, near to the newts, or *vice versa;* but the most unobservant of men could never locate a snake among the birds, nor set a turtle or a crocodile on the same shelf with the swallow or the golden-crested wren.

The first and lowest link of the reptilian segment in the great chain of animal existences commences just above the highest of the amphibian assemblage, and is constituted by the river and mud loving tortoises and the turtles of the warmer seas; while the highest now living embraced the Crocodilian family, in whose membership are included the alligators and jacars of the New World, the crocodiles of the Ganges and the gavials of Northern Africa. The gap between these extremes is filled up by various intermediate gradations. To the tortoises succeeds, according to our best classifiers, a powerful race of long-necked ancient mariners—the plesiosaurs—which hunted their prey by the sea-coasts of the geological middle ages, where they left their bones, the sole testimony to the existence of their race, which became extinct before the chalk-cliffs of England were completed, however long ago that may be. After them comes the large group of the true lizards, comprising, along with several extinct orders, the chameleons, the lizards, and the geckos, both the latter being familiar enough to Continental travelers on sunny spots in Southern Europe; the geckos, especially, attracting attention by their habit of running on ceilings and perpendicular walls, by their sucker-formed toes. The next cohort embraces the serpents—the pythons and boas, endued with a power of crushing almost unsurpassed in the animal kingdom; and the rattlesnakes and cobras, carrying swift and certain death in the lightning stroke of their head. The next place is assigned to the great fish-lizards, or ichthyosaurs, which frequented the deeper waters of the same seas as the plesiosaurs, of whose existence also all knowledge would have perished forever, since they died out leaving no representative to continue their line, had not the kindly mud of the bottom preserved for us fragments of their history in their disjointed bones. Advancing from these "dragons of the prime" we again reach the crocodiles, the most specialized of modern reptiles.

Although between the highest and the lowest of these forms there is nothing like the close bond of union which connects the most distantly related of the birds, yet these diverse families have many charac-

ters in common, separating them from the other divisions of the animal world. Their bodies are protected by modifications of the skin into scales, enormous rugosities of almost impenetrable horny plates or flat shields of various forms. No reptile ever has feathers, for, on account of a peculiarity of the circulation of the blood by which the aërated and unaërated portions mingle together, they are cold-blooded, and therefore do not require so heat-conserving a covering for the body. Most reptiles possess two pairs of legs, of which the fore limb conforms much more closely to the hind in structure than is the case between the anterior and posterior extremities of the bird. On these they crawl rather than walk, their bellies, which are dragged along the ground, assisting in the support of the body; some have both pairs adapted for aquatic life, while others are entirely devoid of progressional appendages. No member of the class can be called a true volant, notwithstanding that a few, such as the flying dragons of the Philippine Islands, are able, by means of membranous expansions of the skin, to sustain themselves in the air while passing from one tree or support to another. With the exception of the tortoises, the majority are carnivorous and possess powerful jaws set with strong, sharp teeth.

So much lies on the surface.

From an examination of the chief points of their internal framework we learn that the "collar-bones" do not unite to form a "merry-thought;" nor does the breastbone develop a median keel. In general the tail is more or less elongated, but its terminal segments do not unite to form a "ploughshare" bone. The leg-bone of the reptile differs from the bird's in having a well-developed fibula lying parallel to it throughout its whole length; it does not present a strongly-marked crest at its upper end, nor is the articular surface of the narrow lower extremity formed by the coalescence with the shaft of a separate bone into a pulley-shaped termination. The coalescence never takes place at all; but each retains a separate existence throughout life. In the situation of the hock in the bird the reptile has at least four distinct bones to which are articulated as many toes; and, lastly, the haunch-bone, instead of being a consolidated mass, is composed of two halves, one on each side, articulating with, but not united by, bony tissue to the spine, and meeting each other below—a character in which the struthious birds, such as the ostriches, agree. It may be remarked, also, that in their keelless breastbone, as well as in the disunion of their collar-bones, these birds present other similitudes to the reptiles.

Every student of osteology is well aware that all bones in their embryonic condition are composed of cartilage, wherein, as the animal grows older, bony spots or "centres" appear, whence the ossification spreads till the whole structure is converted into bone. Among the higher animals these centres are seen only during the earlier years of life, while with increasing age their outlines, becoming gradually fainter, are at length entirely lost. But among the reptiles many of

the bones either continue throughout life with their component parts unsolidified together, or else indicate by clear marks their lines of union, so that it is always easy to tell the number and configuration of which each is composed.

Thus far the characters which separate a reptile from a bird stand so widely apart—the interval between the highest living crocodile and the nearest living bird (represented by such forms as the New Zealand kiwis, the mooruk of Australia, the cassowary of the Moluccas, and the rheas or ostriches of South America) is of such enormous magnitude—that it would seem needless to entertain any fear of mistaking a member of the former group for one of the latter. Meanwhile let us withhold any decided opinion.

On November 29, 1871, a letter to Prof. Dana, dated from San Francisco, written by Prof. O. C. Marsh, of Yale College, New Haven, Connecticut, announced the discovery of a portion of a large headless skeleton in the upper chalk formation of Western Kansas, consisting of the nearly entire posterior limbs, portions of the haunch-bones, several segments from the neck and tail of the spinal column, and numerous ribs all in excellent preservation. The long leg-bone exhibited on the front aspect of its upper extremity the large crest which, as we have already pointed out, is a remarkably Avian character; along its shaft lay a fibula developed as among the diving birds of the present day, to whose thigh-bone also that of the fossil bore considerable resemblance. The "hock-bone," in presenting a trifid pulley-shaped lower end, was bird-like; while in the oblique arrangement of these divisions it again claimed affinities with the divers, whose toes are articulated in this manner to facilitate the forward stroke of their feet through the water, The external division, however, which projects beyond the other two, and is twice the size of either, is developed in a way unknown in any recent or fossil bird, and the bones of the toe supported by it are peculiarly articulated to produce rigidity and prevent flexion, except in one direction, in order by the interlocking of the bones to increase the strength of the joints during the act of swimming; for the whole limb is unquestionably adapted for rapid motion through water. The haunch-bone presents some resemblance to what is seen among the reptiles, in the permanence as separate bones of some of the portions of which it is composed, and in its not being firmly joined to the spine by bony union as in ordinary birds.

The examination so far of these interesting remains proved that the skeleton was certainly a bird's. On comparing its various bones with the corresponding ones in existing representatives, its affinities, notwithstanding considerable divergences from all known recent or ancient species and genera, were evidently with the swimming-birds, of which it is the largest known exponent, and of these it most resembled the great northern diver, near which, for a time, it received a niche with the appellation of Royal Bird-of-the-Dawn (*Hesperornis regalis*).

On September 26, 1872, *Silliman's American Journal of Science* announced the disinterment of another skeleton from the chalk of Kansas, "one of the most interesting of recent discoveries in paleontology." The remains included, among other bones, a number of biconcave vertebræ, that is, having the bodies, or solid central piece of the spinal segments, cup-shaped at both ends, a configuration which obtains, as every one has observed, in the divisions of the backbone of the common cod. This characteristic of the spine is frequent enough among reptiles; but it never occurs among birds met with nowadays. If among them there be any tendency that way, as there is in a few birds, the concavity is invariably found in the posterior end, the rarest form of vertebræ among reptiles. "The neck, back, and tail vertebræ preserved, all show this character, the ends of their bodies (centra) resembling those in the plesiosaurs;" notwithstanding the strongly non-Avian description of the spine, all the other bones—the prominently keeled breastbone, the collar-bone united to form a "merry-thought," as well as the leg- and long wing-bones—exhibit those marks which we have found to be most typical of the bird tribe. The wings were large in proportion to the posterior extremities; and the lower end of the leg-bones is incurved as in swimming-birds. Prof. Marsh, therefore, judging from their relative proportion, concludes that the bones belonged to a bird about the size of a pigeon, in many respects resembling the aquatic birds. He has christened it *Ichthyornis dispar*.

In October of the same year this indefatigable geologist once more announced through the pages of *Silliman* a new "find" from his favorite and fruitful mine in Upper Kansas. This time it was "a new reptile from the cretaceous . . . a very small saurian, which differs widely from any hitherto discovered." The only remains found on this occasion were two lower jaws, nearly perfect, and with many of the teeth in good preservation. The jaws resemble in general form those of an extinct family of marine reptiles whose remains were first found in the chalk formation near Maestricht; but apart from their very diminutive size they present several features which no species of that group has been observed to possess. Noticeably, the teeth are implanted in distinct sockets, and are directed obliquely backward. There are apparently twenty in each jaw, all compressed, with very acute summits. Then there is no distinct groove on the inner surface of the jaws as in all known Mososauroids—as the family of Maestricht reptiles is named. "Clearly," says Prof. Marsh, "the specimen indicates a new genus."

A more careful removal of the surrounding shale brought to light a fact that enormously enhanced the importance and value of this "most interesting of recent discoveries in paleontology." The jaws, which had been accredited to "a new genus" of reptiles, belonged most undoubtedly, from the position in which they were found with reference to the other bones, to the *Ichthyornis dispar*, which owned the spine

with double cup-shaped segments. Here was a dilemma! The ichthyornis had on what seemed reliable data been adjudged a bird; but not only was no bird ever known to have teeth set in sockets, but no bird had ever yet differed so far from its fellows as to affect teeth at all, not to mention the fact of its having resuscitated the fashion of a by-gone day in having its spinal vertebræ cupped at both ends. When it lived, was this creature, in which the types have become so strangely mixed, a reptile, or after all a bird? was a question that for a time made the brows of the philosophers anxious even in the midst of their happiness at the new discovery. They finally declared for the latter. There was, therefore, no resource left but to extend the boundaries which had hitherto confined the avian territory, and institute a new sub-class for its reception, whereat the ornithologists were greatly pleased and cordially welcomed the toothbills among their feathered friends.

Among the treasures which on December 7, 1872, Prof. Marsh and his Yale College explorers brought back to New Haven, as the results of their autumn reaping among the Rocky Mountains, was the nearly entire skeleton, containing all the missing bones, of the royal hesperornis and of another bi-concave vertebrated bird.

The breastbone of the gigantic diver of the chalk is thin and weak, and entirely without a keel; in front it resembles the ostrich's or that of the apteryx of New Zealand—a group of birds presenting the greatest range in time and also the widest geographical distribution over the globe—but in some respects it approaches to the penguin's also. The wing-bones are diminutive, and the wings are rudimentary and useless as organs of flight. The bones that girdle the thigh clearly exhibit a resemblance to the corresponding bones of a cassowary; yet, although avian in type, they are peculiar and present some well-marked reptilian proclivities.

Furnished with these bones alone, and judging from his experience of bird architecture, in plan hitherto undeviated from, no ornithologist would have hesitated to relegate the remains to a place among the birds; and, had he been asked to restore the missing portions, he would in all probability have devised some cross between the corresponding parts of the divers, of the dabchicks (for their knee-cap resembles that of the hesperornis), and of the ostrich-like birds, adding thereto a tail somewhat after the model of the penguin's. Certain it is, however, he would never have approached the features presented by the actual bones. This primeval bird possessed a skull in its general form like that of the great northern diver, but with a less pointed beak. The jawbones, however, though they were originally covered with a horny bill as in ordinary birds, are widely different. They are massive and have throughout their length a deep groove which was thickly set with sharp-pointed teeth—evidence of carnivorous habits—their crowns covered with enamel and supported on stout fangs. In form of crown and base they most resemble the teeth of the reptiles found in the Maes-

tricht beds, to which we have referred above, as well as in the method of replacement, for some of the teeth preserved have the crowns of their successors implanted in cavities in their fangs. This peculiarity in the manner of teeth-shedding is characteristic of some reptiles, each of whose teeth is merely a hollow cone filled in the interior with a soft pulp which supplies the material for the external bony layer. When the tooth becomes worn and useless, a new one is formed beneath the shell of the first by the pulp in the interior, which gradually ousts the old from its socket. In addition to these, the hesperornis possessed other reptilian characters. While the formation of the spinal column in the neck and back is of the true avian type, the structure of the tail, where there have been discovered no fewer than twelve segments, is very peculiar, and differs entirely from anything hitherto seen in birds. The bones of its middle and posterior portions have very long and horizontally flattened processes which prevent all motion in a lateral direction: a peculiarity from which we may certainly infer that, like the beaver's, this appendage was moved vertically, and doubtless was an efficient aid in diving, perhaps compensating for want of wings, which the penguins use with such wonderful dexterity in swimming under water. The last three or four bones are firmly united together, forming a flat terminal mass analogous to, but quite unlike, the "ploughshare" bone of modern birds.

Here, again, is another form half doubtful whether to assume the reptilian or the avian garb, a protestant against the hard and fast lines within which the various groups of the animal kingdom have hitherto been confined. The hesperornis certainly approaches the ichthyornis so far as to come under the new sub-class instituted for the reception of that bird; but, inasmuch as it differs in having its teeth not in sockets but set in a groove, and since, rejecting the conservative bi-concavity in the matter of spinal segments, it has adopted a newer and more high-class "cut," it has been necessary to give to each the honor of heading a separate section.

Though no living bird has so long a tail as this bird-of-the-dawn, yet there was in 1862 disinterred from the lithographic slates of Solenhofen part of the skeleton of a feathered biped—the archæopteryx (the existence of which was foreshadowed by the discovery of a feather the year before), exhibiting in most of the bones preserved the marks of a true bird. In the length of its tail, however, it is peculiar. This appendage contains the enormous number of twenty distinct bones gradually decreasing in size to the last, and each supporting a pair of quill-feathers. To the skeleton no head is attached; but a portion of a small separate jaw on the same slab has been the subject of much controversy as to whether it belongs to the accompanying bones or not. Hermann von Meyer, the illustrious anatomist and paleontologist, holds that there can be little doubt but that they are parts of one and the same skeleton. If this be so, these remains belonged to a toothed bird; and

Prof. Marsh thinks that probably it possessed bi-concave segments in its backbone, indicating, therefore, some alliance with the ichthyornis. The structure of its wings, Prof. Huxley points out, differs in some very remarkable respects from that which they present in a true bird. In the archæopteryx the upper arm-bone is like that of a bird, and the two bones of the forearm are more or less like those of a bird; but the fingers, which in all modern avian representatives are fused together into one mass, are not bound together—they are free. What the number may have been is uncertain, but several, if not all, of them were terminated by a strong-curved claw; so that in the archæopteryx we have an animal which to a certain extent occupies a midway place between a bird and a reptile. It is a bird in so far as its foot and sundry other parts of its skeleton are concerned; it is essentially and thoroughly a bird by its feathers: but it is much more properly a reptile in the fact that the region which represents the hand has separate bones with claws resembling those which terminate the fore-limb of a reptile. Teeth and a long tail, moreover, have certainly been considered hitherto non-avian characteristics.

More recently in our own country there has been brought to light from the London clay, in the island of Sheppey, a skull with the margins of the jawbones armed with larger alternating with smaller denticulations. It has been submitted to the examination of Prof. Owen, *facile princeps* among the restorers of osteological remains, who concludes that it belonged "to a warm-blooded feathered biped with wings"—to a bird, in fact—"and further, that it was web-footed and a fish-eater, and that in the catching of its slippery prey it was assisted by the peculiar armature of its jaws." Many living birds, such as the mergansers or saw-bills, have denticulations on the borders of the horny covering of the bill; but no modern bird has ever the underlying bone elevated into ridges or denticulations like those seen in the London-clay fossil. On the palate, however, of the rare Phytotome, a South American perching bird belonging to the group of the Leafcutters, which bears in its structure many "marks of ancientness," we find two rows of bony denticulations, the remains of what are apparently but recently lost teeth, if we calculate time by the geological horologe, and which may be faint memorials of the dental arrangement seen in the chameleon. Certainly, "they are not the less of interest, seeing that as yet we have nothing else intervening between them and the teeth of the Sheppey fossil." How far this fossil may have resembled any of the avian remains which we have described above, we must wait to know. To conjecture would be dangerous, considering how wide of the mark would have been, in all likelihood, the restoration, had any been attempted, of the hesperornis, whose true structure when revealed so greatly surprised the most experienced naturalists. All that can at present be said is, that the owner of the solitary skull could not have claimed a place within the old avian province. It is

interesting, however, in affording a suggestion as to the possible steps by which the toothbills, as regards the armature of their jaws, may have passed into modern toothless birds.

The Stonesfield slates have yielded up an almost entire skeleton of a wonderful extinct form, unique as yet, described under the name of *Compsognathus*, which possesses a singularly long neck supporting a head whose structure is light, and, except in the possession of teeth, birdlike. Its anterior limbs are small, while the leg-bone of its very long hind-limb exhibits the prominent crest of which we have so often spoken, a ridge on its outer side for the fibula, and the pulley-shaped articular surface of its lower end identical in conformation with that seen in the bird. This skeleton diverges from the bird type, however, in the absence of a "merry-thought," and in having the single hock-bone of the bird replaced by three distinct bones, fitting immovably together, of which the trifid extremity of a fowl's, for example, indicates the coalescence. The haunch-bone, moreover, indicates relationship with the reptiles, in its form and in the manner in which it unites below with its fellow of the opposite side—a feature in which it agrees with the arrangement of the corresponding bone in the crocodiles and in the rheas. This strange creature, bird or reptile, "must, without doubt," Prof. Huxley remarks, "have hopped or walked on its hind limbs after the manner of a bird, to which its long neck, slight head, and small anterior limbs, must have given it an extraordinary resemblance." There is reason for believing that it was possessed of a long tail, which must have greatly helped to support it in the erect position.

The extinct group to which this singular Stonesfield fossil has been assigned contains some of the largest known terrestrial animals, such as the carnivorous giant-lizard (*Megalosaurus*), thirty feet in length, whose structure in many points resembles that of the bird, especially in the form of its hip-girdle and hind-limbs, on which, in the late Prof. Phillips's opinion, it moved with free steps, sometimes, if not habitually, claiming a curious analogy, if not some degree of affinity, with the ostrich. Another example is the still more gigantic herb-eating iguanodon, from beds in Sussex, taller than an elephant and vaster in size, wherein, also, are mingled avian and reptilian characters. In the form of its vertebræ, which, except in the neck, are double-cup-shaped, it is reptilian—in the absence of collar-bones it is non-avian; but in the formation of its three-toed hind limbs, which are larger than the fore, as well as of the supporting haunch-bone, it is distinctly birdlike. Again, it is unbirdlike in regard to its teeth, whose general form and crenated edges are somewhat like the iguanas', which now frequent the tropical woods of America and of the West Indies; but they differ from them in having a flat surface on the crown of the tooth, worn down evidently by the process of mastication, whereas the herbivorous reptiles of the present day clip and gnaw off, but do not chew, the vegetable productions on which they feed.

On the same sands at Hastings there have been found large impressions of the three-toed foot of some biped, the length of whose stride was so great that it is impossible not to conclude that they were made by the hind-feet of one or other of the seventy monsters whose bones have been found scattered about within the narrow area of what was once the banks and delta of a great Wealden river, and which, like the giant-lizards, probably walked occasionally, if not always, on their hind-limbs with their fore-feet elevated in front. The question again arises, nor is it easy to answer, whether these forms should be called reptilian birds or avian reptiles.

In the northern gallery of the British Museum there is a very instructive specimen of a reptile, the frilled lizard of Australia, caught near Port Nelson while perching on the stem of a tree. Its long tail recalls at once the same appendage in the kangaroos, inasmuch as by its position in the stuffed specimen the creature would seem to use it as a support to its body. Its fore feet are much smaller than its hind, and an Australian resident, to whom the specimen was shown in presence of Dr. Günther and himself—so Dr. Woodward tells in a paper read before the Geological Society—remarked that it not merely sits up occasionally, but habitually runs on the ground on its hind-legs without allowing its fore-paws to touch the earth. The edges of its jawbones are elevated into enamel-tipped denticulations, which remind us of those in the jawbone of the Sheppey fossil. In the same slates which have given us the long-tailed reptilian bird and the long-necked, birdlike lizard, there has been found a three-toed bipedal track which "reminded me," said Dr. Woodward, "at once of what the frilled lizard or the compsognathus might produce under favorable conditions. The slab presents a median track formed by the tail drawn along on the ground; the two hind-feet with outspread toes leave their mark, while the fore-paws just touch the ground, leaving a dot-like impression on either side of the median line. The median track is alternately stronger and fainter. Since the tail of the archæopteryx is bordered all the way by feathers, it will at once be seen that it could not leave behind a clean, simple furrow, but a broad smudge composed of many lines, while the tail of a lizard, progressing by hops and supporting itself on its hind-limbs and tail, would produce just such an impression.

There is yet another interesting group of extinct forms to which we would refer shortly, termed "winged reptiles, or flying dragons." In the Woodwardian Museum, at Cambridge, there is a large collection of these bones, belonging to many species, from the soft marl in the neighborhood of that town, about which there have been entertained the most diverse opinions by the most eminent naturalists. They have been variously held to belong to bats, to forms between birds and mammals, to reptiles, and even to dolphins. Prof. Huxley finds in them great resemblances to birds; Prof. Owen thinks that they are reptilian remains; while Prof. Seeley, judging from the form of the cranium, is

of opinion that these flying dragons "had a brain indistinguishable from a bird's."

They are all remarkable for their great proportionate length of head and neck, for in some the lizard-like and in others the birdlike length of tail, and for the large size of the fore-limb, which, quite unlike the same extremity in a bird, was terminated by four digits, whereof three were clawed, while the clawless fourth or little finger was enormously elongated to support the outer edge of an expansion of the integument like the wing of a bat. The bones of the hind-limb and of the haunch differ widely from the bird type; nevertheless, air-passages, such as characterize no other kind of skeleton, are met with in the bones of the head, of the spine, and of the fore and hind limbs, often coinciding identically in situation with those in birds, and indicate, according to Prof. Seeley, a system of air-circulation from the lungs similar to what is found in birds. From this he argues the existence in these gigantic volants of warm blood, and of a heart similar to the bird's in construction. They have the breastbone broad, strongly keeled, and unlike that of other reptiles; there is evidence also that the jaws were incased in a horny sheath. On these considerations, therefore, it is held that, as far as the skeleton indicates, their differences from birds are much less than the differences between the several orders of mammals or reptiles. The same paleontologist has made careful casts of the interior of the skull, and, from the position of certain lobes whose distance or proximity distinguishes the brains of modern birds and reptiles, he says in an interesting paper on the subject in the Linnæan Society's "Transactions" for 1876: "The resemblance of form and arrangement of parts between this fossil animal's brain and the brain of a bird amounts, as far as the evidence goes, to absolute identity; no more perfect specimen could add to the force of the conclusion that its brain is an avian brain of a typical structure. Since brain and lungs are organs of incomparably greater value in questions of organization than fore and hind limbs—organs in which, according to Prof. Huxley, they depart most widely from the bird type—the flying dragons on the whole are very reptilian birds rather than very avian reptiles."

The Solenhofen stone preserves not only bones and hard parts, but even the cutaneous characters of its old inhabitants. It shows casts of the down and feathers, impressions of the fine foldings or wrinkles of thin expansions of naked skin, as well as of delicate tendons. Prof. Owen, therefore, thinks that if the flying dragons had possessed any plumose clothing it would in all probability have been preserved, and, as no such indications (but contrariwise, several genera undoubtedly had their body-covering hardened into bony scales, sometimes produced into prodigious spines) have been discovered, though the Oolitic mud has entombed the greatest number and variety of these beings, he concludes that they were cold-blooded, as other reptiles are; whereas, if they had been warm-blooded, they would have possessed feathers, as

their contemporary the archæopteryx did; for the constant correlative structure with hot-bloodedness is a non-conducting covering for the body. Prof. Huxley, on the other hand, differing from this anatomist, thinks that, judging from the air-passages in their bones, they were warm-blooded, but that, nevertheless, they were reptiles with special modifications for special purposes.

It would, therefore, appear that we are again face to face with a group which the most eminent authorities are far from agreed whether to regard as reptiles or as birds.

We have now passed in review various remarkable forms—living birds and living reptiles, separated by an immeasurable distance from each other, and forms which have so mingled the characters of both as to present great difficulties to their being included among the members of either group. Starting from the groveling crocodile, we have seen that there existed gigantic crocodile-like forms, such as the giant-lizard and the iguanodon, that walked, sometimes at least, on their hind-limbs; others, like the long-necked, long-tailed compsognathus from the Solenhofen slates, that hopped on the ground after the manner of a bird; then "flying dragons," with birdlike brain and bones that cleft the air with their twenty-feet expanse of wing; next, undoubted birds, with toothed bills, the one with reptilian vertebræ, the other with a beaver-like tail; while last of all, omitting the imperfectly known Sheppey fossil, the feathered archæopteryx whose twenty caudal segments bar its entrance to every existing family of birds.

Without by any means asserting—what is not only far from being ascertained fact, but is indeed very improbable; for we are not in a position to state that they appeared on the earth intermediately between the two groups—that these forms are the direct terms in the series of progressions from reptiles to birds, we can, in their intelligent contemplation, without overstraining the imagination or violating our reason, picture still more modified forms wherein the reptilian and the avian types would so harmoniously blend that we should find it impossible to say, "At this point the line between reptiles and birds must be drawn." There can be no reasonable doubt but that the remains, which only through the circumstance of a happy burial have been preserved to us from the second great era of the world's history till now, are no more than a very few examples with many a blank between of the fauna which has lived and died, whose tombs no man knoweth. Moreover, it seems easy enough to believe, after studying these forms, that, could any human eye have followed from that day to this the waxing and waning of the various animal groups, he could have constructed for us a marvelous chain of existences between reptiles and birds, the conformation of whose unknown links we can almost fabricate in our minds, between which no abrupt transitions harshly jarring would occur, no stepping-stones too wide to stride across; and, handing on to us, besides, the traditions of a still earlier time, he could have pictured

to us the whole of living Nature, each varied offshoot fitly joined together, sloping gently back along the vast converging lines of ordinary generation to one grand starting-point, wherein till the fullness of time every living thing, from the microscopic diatom to the giant sequoia, and from the shapeless amœba to the stateliest of bipeds—

"Lay hidden, as the music of the moon
Sleeps in the plain eggs of the nightingale."

—*Belgravia.*

THE PLANET VULCAN.

By Professor DANIEL KIRKWOOD.

THE discovery of an intra-Mercurial planet during the total eclipse of July 29, 1878, has given new importance to any previous speculations on the question of its existence. A brief historical review of the subject will not be without interest.

In an article by the writer, "On the Probable Existence of Undiscovered Planets," written immediately after the discovery of Neptune, and published in the *Literary Record and Journal of the Linnæan Association of Pennsylvania College*,[1] the question was thus considered:

"The distance from the centre of Jupiter to the nearest satellite is about three times the equatorial diameter of the primary. If, therefore, we suppose the distance of the nearest primary planet to have the same ratio to the diameter of the sun, the orbit of such planet will be somewhat less than 3,000,000 miles from the sun's centre. Consequently, in the interval of 37,000,000 miles there may be four planets, the orbit of the nearest having the dimensions above stated, and their respective distances increasing in the ratio of Mercury's distance to that of Venus. Such bodies, however, in consequence of their nearness to the sun, could hardly be detected except in transiting the solar disk."

It is well known that the disturbing influence of the other planets causes an advance in the position of Mercury's perihelion. In a century this change amounts to 10′ 43,″ which, according to Leverrier, is 38″ more than can be accounted for by the influence of the known planets. This great astronomer inferred, therefore, that a planet, or possibly a zone of extremely small asteroids, must exist within the orbit of Mercury.

The conclusions of Leverrier were communicated to the French Academy in the autumn of 1859. Soon after their publication Dr. Lescarbault, an amateur astronomer as well as a medical practitioner of Orgères, some forty miles southwest of Paris, announced that, on March 26, 1859, he had observed the passage of a dark circular spot across

[1] Vol. iii., April, 1847, p. 131.

the sun's disk, which he thought might have been the transit of an intra-Mercurial planet. He stated further that he had delayed the publication of the fact in the hope of obtaining confirmatory observations. On the appearance of this statement Leverrier at once determined to seek an interview with the observer, in order to test the truth of his discovery. With the details of this interview the public is familiar. After a thorough examination of Lescarbault's original memoranda, as well as of his instruments and methods of observation, Leverrier was satisfied that the amateur astronomer of Orgères had really observed the transit of an intra-Mercurial planet. From the notes furnished by Lescarbault, the director of the Paris Observatory estimated the period of the planet at nineteen days seventeen hours; its mean distance from the sun, 13,000,000 miles; the inclination of its orbit, 1° 10′; and the greatest elongation of the body from the sun, 8°. The apparent magnitude of the solar disk, as seen from Vulcan's estimated distance, is fifty times greater than as seen from the earth.

The sun was again watched during the last days of March in 1860 and 1861, in the hope of reobserving the new member of the system. The search, however, was unsuccessful until March 20, 1862, when Mr. Lummis, of Manchester, England, between eight and nine o'clock A. M., observed a perfectly round spot moving across the sun. Having satisfied himself of the spot's rapid motion, he called a friend, who also noticed its planetary appearance. From these imperfect observations two French astronomers, MM. Valz and Radau, computed elements of the planet: the former assigning it a period of seventeen days thirteen hours; the latter, one of nineteen days twenty-two hours. From 1862 to 1878 the planet was not seen, or at least no observation was well authenticated. The transit of Mercury, however, on May 6, 1878, afforded new evidence of the truth of Leverrier's theory that Mercury's motion is disturbed either by a planet or a zone of planetary matter within his orbit.

We must now refer to a very unpleasant incident in the history of this interesting discovery. This is nothing less than the charge, by an eminent astronomer, that the observations and measurements claimed by Dr. Lescarbault were a pure fabrication. M. Liais, a French astronomer employed at Rio Janeiro by the Brazilian Government, claimed to have been engaged in an examination of the sun's surface with a telescope of twice the power of Dr. Lescarbault's, at the very time of the latter's alleged discovery of the planet. M. Liais says, therefore, that "he is in a condition to deny, in the most positive manner, the passage of a planet over the sun at the time indicated." The weight of this negative testimony has, perhaps, been over-estimated; and Lescarbault, who for eighteen years has quietly submitted to the charge of falsehood and dishonesty, may perhaps yet retort that, if M. Liais was examining the sun at the time referred to, his merit as an observer cannot be highly rated.

But the astronomer of Brazil did not stop with denying the truth of Lescarbault's observations. He boldly called in question the conclusion derived by Leverrier himself from a laborious discussion of the observed transits of Mercury. It now appears, however, that in this case also his position was most unfortunately taken.

It has been frequently said that if an intra-Mercurial planet exist, of any considerable magnitude, it ought to be visible during total eclipses of the sun. But who has not remarked the difficulty of finding a small or faint object when we know not where to look for it, and how easily it may be found when its position has been once pointed out? Mitchel's detection of the companion of Antares and Clark's discovery of that of Sirius are cases in point. Fortunately, however, neither argument nor explanation is any longer necessary. The new planet was undoubtedly seen during the total eclipse of July 29, 1878, by two astronomers, Prof. James C. Watson, director of the Ann Arbor Observatory, and Mr. Lewis Swift, of Rochester, New York. The former is the discoverer of more than twenty asteroids; the latter is an amateur, who has detected several new comets. Prof. Watson was stationed at Separation, Wyoming Territory. The planet was not found by him till half the time of totality was past. It was about 2½° southwest of the sun, and appeared about as bright as a 4½ magnitude star. Mr. Swift, who selected a position near Denver, Colorado, took with him his excellent comet-seeker for the special purpose of searching for intra-Mercurial planets. Two stars were seen by him at the estimated distance of 3° southwest of the sun. They were of the same magnitude—about the fifth—and at a distance apart of six or seven minutes. A straight line drawn through them pointed very nearly to the sun's centre. Mr. Swift supposed one of the stars to be Theta Cancri. The other was doubtless the planet observed by Prof. Watson, although the estimated distance from the sun was somewhat greater. Both observers describe it as a *red* star. According to Prof. Watson, "it shone with an intensely ruddy light, and it certainly had a disk larger than the spurious disk of a star." Its appearance in the telescope indicated that it was approaching its superior conjunction, or, in other words, was situated beyond the sun.

The distance of Vulcan from the centre of the system, though still uncertain, is supposed to be about one-seventh that of the earth. If this estimate be nearly correct, the solar light and heat at its surface must be about fifty times greater than at the surface of the earth. The corresponding period is nearly twenty days. In other words, Vulcan's year is believed to be less than three weeks in length. The sun is twenty-five days in completing its axial rotation; so that in the new planet we have probably another instance in which, as in the case of the inner satellite of Mars, a planetary body performs its orbital revolution in less time than is occupied by the central orb in completing its rotation. Again, as seen from the sun's surface, all the old planets

rise in the east and set in the west. But this is reversed in the case of Vulcan. It rises in the west, and, after having been fifty-seven days above the horizon of any point in which the plane of its orbit intersects the sun's surface, must set in the east.

But it is useless to speculate in regard to the elements of this planet's orbit, its magnitude, physical constitution, etc. It ought certainly to be found near its greatest elongation by some of the powerful telescopes now in use. When so detected a few observations will furnish data for the complete determination of its period and distance, together with the form and inclination of its orbit.

The interesting observations of Prof. Watson and Mr. Swift will not only stimulate astronomers to renewed search for the planet so fortunately detected, but must lead also to a more thorough examination of the space within Mercury's orbit. It is not improbable that the detection of Vulcan may be merely the first in a series of similar discoveries.[1] The solar disk will doubtless be closely watched about February 11th–17th, March 19th–27th, and October 1st–14th, as it has been claimed that at these epochs small round spots have been seen passing across the sun. In short, the prospect of planetary discoveries in this part of the system is at present more hopeful than in the space beyond the orbit of Neptune.

THE GENESIS OF DISINTERESTED BENEVOLENCE.

By PAUL FRIEDMANN.

DISINTERESTED benevolence, about the genesis of which so much has been written, is a name for two distinguishable things. It is in some cases meant to designate that feeling which prompts us in a special instance to do good to some individual object. In other cases, the same name is applied to the quality of the mind which predisposes to all special benevolent impulses. But these two are of course not the same thing, and when I inquire into their origin I shall have to consider them separately. This, however, I shall do in an order the reverse of that commonly adopted, beginning with the special sentiment, and then inquiring into the general quality of the mind.

Benevolence, in the first sense, may be defined as the wish that the object of this feeling may be well—as the wish for the welfare of something. In so far as, with a certain class of beings, welfare is accompanied by pleasure or happiness, benevolence is a wish for the

[1] It has frequently been noticed that astronomical discoveries occur in clusters, separated by intervals comparatively fruitless in great results or important observations. Thus, from the epoch of Cassini's discoveries to that of Sir William Herschel's—nearly a century—no new planets, primary or secondary, were added to our system.

pleasure or happiness of the object. But I should think it a great mistake to define it in this latter way. It would reduce the field of benevolence by excluding all inanimate beings, and make the definition far too narrow. Benevolence, I assert, can be felt quite as well toward inanimate, non-sentient beings as toward sentient organisms. It can be felt toward any being of which it is believed that its welfare or perfection can be procured. As the parent toward his child, the master toward his dog, so the sculptor feels benevolence toward his statue, the author toward his book. The perfection of it makes him happy, its imperfection or destruction causes him pain. Whether the object is a living being or not, whether it is real or imaginary, the sentiment of benevolence is the same in all cases.

Disinterested I shall call such benevolence, if its origin cannot be traced directly to some egoistical motive or to some other moral or æsthetic feeling. Gratitude, which is dictated by a feeling of equity, admiration, which takes its origin in an æsthetic judgment, or the aversion to inflict pain, which is the result of our habits, I shall not call disinterested benevolence, and in this short essay I do not inquire into their origin.

To explain the growth of the special sentiment of disinterested benevolence I must assume a certain number of qualities of the mind, the existence of which, however, has generally been admitted. Whether these qualities are native or acquired is here of no importance; all I require is that they be found in man very soon after his birth. These qualities are, first, the impulse toward self-preservation and self-augmentation inherent to every living organism, and without which it could not exist and develop itself; the wish to be and to be more and more, in a word, to grow. The second quality of mind which I have to assume is the consciousness of existing, not only as a passive sentient being, but as an active being too. And these two qualities once admitted, there follows from them a third, which is the wish to exist as an active being either actually or potentially, to be either acting or capable of acting—the wish for power. The fourth quality is that known under the name of capacity of associating ideas, and the fifth the capacity and tendency of the mind to fuse or confuse such associated ideas, so as not to distinguish them any longer from one another. The first four qualities just enumerated have long ago been generally admitted and amply illustrated. The fifth, that of confusing ideas, has likewise been admitted; it has even been most admirably illustrated in the works of many a philosopher of great repute, but I am not aware that its importance for morals has ever been sufficiently insisted upon.

The specimen case of confusion is that between the ego and the body. All men in early life confuse the two notions of self and body, and most men continue to do so forever. Here already the confusion produces a kind of disinterested benevolence; we feel well inclined toward our body irrespective of any advantage to ourself.

But it is not from this simplest form of the mental quality that moral benevolence takes its rise. Besides the confusion just spoken of, there is another, the outflow and consequence of that between body and mind, nearly as common among children and uneducated men. It is the confusion between the acts of ourself, of our mind, and those of our body; between intended effects and willed acts.

This confusion is to be found in the laws of all rude and semi-barbarous nations. Their criminal codes punish the result of an act irrespective of the intention of the agent; they make, for instance, no difference between murder and manslaughter. In more civilized countries, where generations of lawgivers have for centuries developed the theory of criminal responsibility, the law is even now far from perfect. The result of an act, even when not intended, continues to be taken into account for punishment. A man who would be let off with a small fine for an illegal act producing no direct harm would be fined more heavily, or even imprisoned, if by such an act some harm were unintentionally done. Even if the legislator wished to correct this irrational state of the law, the general opinion of the uneducated majority would prevent him from doing so. It will be long ere the theory of criminal responsibility is generally understood.

But if in criminal law, which it is the interest of so many persons to clear up, the confusion still exists, how much the more will it continue in those matters where no great interest is at stake! If a man kills another man, fear of punishment, fear of his own conscience, will prompt him to consider whether the death was intended or not, whether he is guilty of murder or of simple manslaughter. But, if a man by mere chance does some good to another man, there is nothing which incites him to a similar mental effort, while on the contrary the agreeable sense of power which the consciousness of the effect produces, the gratitude of the benefited individual and the approbation of society, will make the idea that he is the author of the benefit pleasant to him and prevent him from too closely analyzing his motives. He will easily assume that he is the author of the benefit, and so it happens that, when an act of his body has produced a beneficial result upon some one else, an average man thinks that he himself has done good to that individual.

From this confusion real disinterested benevolence will take its origin. The agreeable sense of power, produced by the unintended beneficial effect, will continue as long as the agent can remember that effect. This, however, will only be the case if the benefit persists for some time, so that it may hereafter be remembered, and it will be all the more the case if that benefit continues for a long time so as to be actually perceived. There is, then, an inducement so to act that it may persist. This inducement is of course very weak at first, and will produce no action if there is not a considerable spontaneous energy. But there is already a germ of benevolence, the wish that a benefit con-

ferred upon some individual may subsist. And if this sentiment under favorable circumstances produces further action, this time intentional, it will become stronger thereby; far more power is felt to be exerted, and more interest is consequently felt in the effect. The wish to maintain the effect increases in proportion to the exertions already made, and it may finally become strong enough to overcome counteracting influences of considerable moment.

But this is not all. As it is a condition of the persistence of the beneficial effect, that the being upon whom it has been produced continues to exist, a secondary wish, very slight at first, will be generated, that the whole individual may continue to be. At the same time that the wish for the persistence of the beneficial effect becomes stronger, this secondary feeling augments and may produce action tending to the conservation and the welfare of the individual benefited. But, as soon as the fact is realized that good has been done to the whole individual, this new secondary benefit will become the starting-point of a growing disinterested benevolence, directed no longer toward a single quality but toward the whole being. The secondary feeling may now grow much quicker than the primary one, which may in due time be entirely forgotten, and nothing will remain but true disinterested benevolence toward the individual. A benefit conferred by mere chance has produced true devotion.

To illustrate my meaning, which otherwise might remain obscure, let me adduce an example: A man had to throw away some water, and, stepping out of his house, threw it upon a heap of rubbish, where some faded plants were nearly dying. At that moment he paid no attention to them, took no interest in their pitiable state. The next day, having again some water to throw away, the man stepped out at the same place, when he remarked that the plants had raised their stems and regained some life. He understood that this was the result of his act of the day before, his interest was awakened, and, as he held a jar with water in his hand, he again threw its contents over the plants. On the following day the same took place; the benevolent feeling, the interest in the recovery and welfare of the plants augmented, and the man tended the plants with increasing care. When he found one day that the rubbish and plants had been carted away, he felt a real annoyance. The feeling of the man in this case was real disinterested benevolence. The plants were neither fine nor useful, and the place where they stood was ugly and out of the way, so the man had no advantage from their growth. Nor had the man a general wish to rear plants, for there were a number of other plants sorely in want of care, but to which the man did not transfer his affection. He had loved those individual plants; the benevolence toward the effect he had at first produced had by confusion become benevolence toward the plant itself, and the first feeling had been entirely forgotten.

In this case there was a complete confusion between the effect and

the recipient of it, rendered easy by the fact that, by continuing the special benefit, the whole welfare of the plant was assured. But such is not always the case. If the benefits have all been of one and the same kind, if the benefactor has been prevented from extending the sphere of his beneficial action, the feeling of benevolence will remain in its primitive state, directed toward one quality of the individual. However strong it may become, it will never extend to the whole being.

Cases of this kind are by no means rare, but they are generally misunderstood. We assume that A feels benevolence toward B, and that, if he lays so much stress on a single quality of the latter, this arises from an error of judgment as to what is good for B. In reality the error of judgment is ours, and the man whose folly we condemn is intellectually quite in the right. Having never learned to love B, but only to love one of his qualities, A favors this latter even to the detriment of the holder.

In the first example adduced by me, benevolence took its origin in a chance act, no effect at all having at first been intended. This is not necessarily the case. A benefit may be intended in a limited degree, for instance, as an equivalent for a benefit received. The spring of action here is gratitude, based on equity. But, while this benefit is conferred, a benevolent feeling, first, toward the special quality furthered, and, finally, toward the whole individual, may arise in exactly the same manner in which it arose from a chance act. Gratitude will be forgotten, and disinterested benevolence felt instead. One moral feeling has here given rise to another; equity to disinterested benevolence. In our social system this latter genesis will be most common; it is only where social relations are rare that benevolence will commonly be produced as a consequence of a chance act. But, in all cases it will be a necessary condition to the perfection of the feeling, that it be extended to the whole individual, as else it may often tend rather to injure than to favor this latter.

My meaning, I hope, is now sufficiently explained. It remains to be seen how far my theory is in accordance with the known facts about benevolence. For this I hold to be the indispensable test of every psychological theory—that it will offer an easy explanation of the facts known from experience; and this test I shall now apply.

The strongest feeling of benevolence on record is probably the love a mother bears to her infant child. The strong feeling that she has given it life, that the child is her creation, explains the energy of the affection. This is further strengthened by the consciousness, that by nourishing and tending her child she confers constantly new benefits, indispensable to its welfare. But, as the child grows up, this benevolent feeling may, with mentally undeveloped persons, lose much of its power. When the child becomes independent, when it is no longer in want of the maternal care, the maternal affection will cool down or turn

toward a younger child still in need of its mother's help. This is already apparent in the lower races of mankind, but much more so among the higher animals. Among these latter a mother will risk her life to defend her young, but, when they are grown up, she does not care for them in the least.

Among uneducated people paternal affection is seldom very strong toward an infant. Some culture of mind is necessary to realize all the indirect benefits the father at first confers. But, when the direct influence becomes considerable, the paternal affection augments and may assume a very great energy. Among animals paternal affection, I think, exists only in those species in which the father assists the mother in rearing and feeding the little ones, as, for instance, among birds.

During the proscriptions of Marius and Sulla, there were many sons who out of fear gave up their father, but it was never known that a father had denounced his son; a fact that somewhat startled the Roman moralists, who were unable to explain it. Upon my theory the explanation is easy enough. In Roman society the son could confer no benefit upon his father, and the mere feeling of gratitude for the benefits received from the parent was not sufficient to counterbalance the fear of the bloody edict. Filial affection can indeed become very strong, but, whenever it does, it is easy to perceive that the parent has in some way become dependent on the child—has received benefits from him.

The relations between man and wife are such that the two are called upon to complete one another—that they have a fair opportunity of conferring great benefits without a corresponding sacrifice or exertion. The facility renders the feat all the more attractive, and strong affection follows upon it.

That friendship is based upon numerous mutual benefits is a fact daily seen. Prevent a friend from doing you good, impress him with the idea that he is of no use to you, and his affection will cool. But ask a man for little services he is ready to render, let him know and keep in his mind that he has conferred a benefit upon you, and he will like you all the more for it, become interested in your welfare, and finally feel real devotion for you. I have never known the experiment to fail.

In public life those who receive the greatest benefits from the community are not the men most ready to make any sacrifice for the general good. Patriotism, I think, is not exactly rampant in workhouses, though the inmates owe everything they enjoy to the munificence of the public. The pauper who has done no good to his country, who, on the contrary, is a continual burden to it, feels no benevolence toward it.

On the other hand, a man in the higher ranks often enters the public service, either to earn in an easy way a sufficient income or out of ambition, and in order to gain fame. If such a man by his energy or by some distinctive talent becomes useful to the state, in most cases

he will become a really patriotic citizen. The official will devote more than the strictly due time and energy to the fulfillment of his task, the statesman will give up his personal ambition, and often risk what must be dear to him, popularity and power, in order to carry the measures he thinks necessary to the welfare of his country.

And when some extraordinary man has made a discovery, has introduced a measure or proclaimed a truth beneficial to the whole world, the sentiment that he has been useful to so many millions of people gives a distinctive character to his benevolent impulses. Such a man, the benefactor of humanity, will refuse his sympathy to no part of it; he will at once feel benevolence toward any man with whom he comes into contact. He knows that he has done him some good, and is well inclined toward him.

I hope I have now shown that my theory agrees with the facts known by experience, that it can bear the crucial test. That being so, I think myself entitled to hold that the genesis of every single benevolent sentiment is that some good is done to an individual, either unintentionally or from another motive than that of disinterested benevolence, as from gratitude, sense of equity, religious feeling, or hope of advantage, and that, the benefit itself being loved by its author, this love or disinterested benevolence is by confusion extended to the individual upon whom the benefit has been conferred and maintained. It now remains for me to explain how, from single benevolent feelings, there arises a general benevolent disposition, how the benevolent character is formed.

I think we shall again have to trace back the origin of the benevolent disposition to confusion. After having felt benevolence toward a number of individuals of a class, we come to confuse them with one another, and to transfer part of our feeling to the whole class. When any member of it presents itself, benevolence is at once excited.

That such is the case will appear more clearly if we remember how often we are favorably disposed toward a perfect stranger, simply because in his outward appearance, his manner, his voice, or any other characteristic, he is like some other person we love. We have a confused but strong benevolent feeling toward a cluster of attributes belonging to the friend we have learned to cherish. Some of these attributes are suddenly and strikingly presented to us, and we feel well inclined toward them. We confuse the attributes with the present possessor of them, and benevolence is felt toward the stranger. In this case the genesis is so clear, the confusion so glaring, that they cannot be overlooked. In other cases they will not be so apparent, but the process will be the same. The cluster of attributes—man, Englishman, or man of a certain type—is liked, because a number of persons dear to us possess these attributes. Men of another type or nation are often not liked at all, even by such people as are generally considered benevolent. The difference in this case is stronger than the

likeness, and no confusion is made. What holds good of men holds good equally of all other beings. I have observed this genesis in myself; formerly rather hostile to dogs, now that I have a dog myself, I feel well inclined toward the whole canine species, but most to that part of it which has some characteristic feature in common with my favorite. This, then, is the genesis of the benevolent disposition, that, after having by confusion become well inclined toward certain things, we feel the same benevolence toward each of their attributes; when we find these attributes in other things, we feel equally well inclined toward them, and by confusion extend this benevolence to the individual possessing the attribute. Hence it follows that the greater the diversity among the individuals toward whom we acquire a benevolent feeling when young, the wider the range of our sympathies, of the benevolence we feel at once toward those with whom we come in contact—a fact of some importance in educational science.

I do not know whether I shall have convinced my reader of the soundness of my theory. Limited space and an inadequate power over the language may have prevented me from attaining this end. But the question is so important that even the mere suggestion of a possible theory might be accepted as of some use toward the final solution of the problem, and as such I offer the foregoing pages.—*Mind.*

SKETCH OF CLAUDE BERNARD.

CLAUDE BERNARD died at Paris, in February, 1878, in the sixty-fifth year of his age. The nineteenth century produced Magendie, Flourens, Johannes Müller, Charles Bell, Marshall Hall, and others, who made great discoveries in human physiology; but none of these great men did more for the advancement of knowledge in this direction than the subject of our sketch. Bernard was a pure physiologist; and, in his day, he was recognized as the great exponent of the experimental school. His name is connected with important discoveries in nearly every department of human physiology, and the influence of his method has borne fruit wherever this science is studied.

The career of Claude Bernard is a most interesting and instructive chapter in the history of the progress of physiology for the past thirty-five years. The accounts of his life which have appeared in the French journals give little information with regard to his early life. It is simply stated that he was born in the village of Saint-Julien, near Villefranche (Rhône), on the 12th of July, 1813, where he studied pharmacy. When about twenty-one years of age, he went to Paris with the manuscript of a tragedy. He had written a *vaudeville*, which had been represented at Lyons; it is not said with what success, but prob-

ably he had been encouraged sufficiently to lead him to seek for fame as a playwright. Upon his arrival at Paris, he formed the acquaintance of Prof. Saint-Marc Girardin, who induced him to give up his purely literary aspirations, and to enter upon the study of medicine. In 1839 he became an *interne* in the Paris hospitals, where his remarkable talents were soon recognized. Very early in his career he published a large and superbly illustrated work upon "Operative Surgery," in connection with M. Huette. This work was translated into many foreign languages, and met with great success; but his distinguished reputation as a physiologist, which dates from about 1848, afterward became so extended that his writings upon surgery have almost been forgotten.

In 1843 he discovered the nerve which gives the sense of taste to the anterior portion of the tongue.

In 1844 he made important advances in the knowledge of digestion by the stomach, following the discovery of the properties of the gastric juice in 1833, by Dr. Beaumont, an American physician.

In 1848 he discovered the production of sugar by the liver, which had not before been even suspected. At about the same time he discovered the digestion of fats by the pancreas, a fact of great physiological importance.

In 1844 he discovered the nerve which presides exclusively over the voice.

In 1847 he fully described, for the first time, the digestive properties of the secretions of the different salivary glands.

About 1853 he devised an accurate method of estimating the gases of the blood, and he did more than any of his predecessors to advance our positive knowledge of the process of interchange of gases in respiration.

His researches in the physiology of the nervous system were most extensive. He did more than any one before to illustrate the mechanism of secretion and excretion, and the influence of the nervous system over the action of glands. He was the first to fully and accurately describe the properties of the woorara poison, which is now so largely used in physiological research. It would be impossible, within the limits of this sketch, to give a comprehensive and intelligent account of Bernard's original investigations. Within the last twenty-three years he has published fifteen volumes upon subjects connected with physiology, embodying the results of his original work. He constantly and powerfully advocated the experimental method, and his dexterity in vivisection was truly marvelous. While he was at the zenith of his fame, nearly all physicians who visited Paris attended his lectures or witnessed the experiments in his laboratory. To all he was uniformly courteous and communicative; and the success of the demonstrations with which his lectures were profusely illustrated created the greatest enthusiasm. Between the years 1859 and 1865 he published very little, being in feeble health. During this time his thoughts must have

been directed more toward general physiology than before; and the first volume of lectures, published after his health had become partially restored, was more philosophical in its scope than his earlier writings. Still, his tendency was always toward original investigation, and, in his reasoning, he closely followed the deductive method.

It is difficult for one who has not followed closely the progress of physiology for the past quarter of a century to appreciate the full merit of the original work accomplished by Bernard, and the immense influence which he and his followers have exerted by the impulse they have given to the experimental and deductive method. His studies in the nervous system resulted not only in a number of important discoveries, but in the adoption of many entirely novel methods of experimentation. His discovery of the production of sugar by the liver gave the first definite idea of the possible function of a ductless gland. The discovery of the digestion of fats by the pancreas gave to physiologists the first positive fact with regard to intestinal digestion. The discovery of the influence of the sympathetic system of nerves over animal heat, made in 1851, opened the subject of the relations of the nervous system to nutrition and the action of the vaso-motor nerves; and examples of this kind might be largely extended in number.

The importance of the labors of Bernard was fully recognized in France, where he long held the highest professorial positions, and was the recipient of many honors from his government. He was assistant and prosector to Magendie from 1841 to the time of the death of Magendie in 1855, and acted as his substitute at the College of France from 1847 to 1855. In 1843 he took his medical degree. In 1853 he took the degree of Doctor of Sciences, and was appointed to the chair of General Physiology which was created for him at the Faculty of Sciences. In 1855 he succeeded Magendie as Professor of Medicine at the College of France. In 1868 he was appointed professor at the Museum of Natural History. He was elected a member of the Academy of Medicine in 1861, perpetual President of the Society of Biology in 1867, and a member of the Institute of France in 1869. In 1867 he was appointed commander in the Legion of Honor, and Senator of France in 1869. At the time of his death he was a member of most of the learned societies of Europe, and of several in America. In the French Chamber of Deputies, when his death was announced, his memory received the unusual honor of a unanimous vote decreeing that his funeral be conducted at the expense of the state.

Such, in brief, was the career of one who was the greatest physiologist of the nineteenth century. His labors extended over a period of thirty-five years. They were untiring and most fruitful in practical results. It may be truly said that he ended his work only with his life, and he corrected the last proofs of a series of lectures, published after his death, upon the bed of sickness from which he never arose.

EDITOR'S TABLE.

THE SCIENTIFIC ASSOCIATIONS.

THE American and British Associations for the Advancement of Science have again assembled in their customary annual meetings, the former in St. Louis, and the latter in Dublin. The American meeting was not large, its location being unfavorable to draw people from remote distances in the heat of August. But a fair amount of work seems to have been done, as those who came were interested and active men in their several departments of science. The chief event of the session seems to have been, as it undoubtedly should be, the delivery of the presidential address. President Newcomb wisely chose a topic of general interest, and, moreover, did not hesitate to enter boldly upon the discussion of questions of a high philosophical character, and concerning which the mind of the age has by no means settled down into the repose of unanimity. He considers the scientific method of thinking, as contrasted with the theological method, and pictures the progress of scientific thought in clearing away the old theological interpretations of Nature, and giving us a new and truer view of the realities and method of the universe. The doctrine of teleology, of final causes, or ends to be secured in the economy of Nature is instructively discussed, and the influence of science in doing away with this mode of viewing the course of things is well pointed out. The addresses given before the sub-sections of the Association were meritorious on their several topics, and we are glad to see that Prof. Grote, in his address on "Education as a Succession of Experiences," went into the grounds of scientific education, and made a forcible appeal to the body to take a deeper interest in the work of diffusing science and bringing its influence to bear more directly upon the schools of the country in respect of their scientific teaching. He says:

> "The demand has come up from teachers throughout the country that they should be better informed as to the manner in which the sciences may be introduced into the schools, and the matter to be taught. It is the duty of this Association to furnish such information. If we have not sympathized with this inquiry in the past, let us assist it in the future. It is quite evident that the sooner it commits itself, as a matter of principle, to the furtherance of science among the people, the more following it will have and the greater influence. The Association must be prepared to demand more time for scientific studies from the public school authorities, and it must show that education in this aspect of it is a matter that not only falls properly under its cognizance, but which it is also prepared to take hold of."

These are wise and weighty words, and we hope they will be heeded in conducting the future operations of this body.

The British Association had a large and successful meeting in Dublin, to one feature of which we desire to call attention, as worthy of imitation by the American society. The British Association admits members each year called "associates," which may consist of strangers, citizens, ladies, or anybody who wishes to join without any regard to scientific qualifications. They, of course, take no part in the business, and merely enter into social relations with the body for the time being, but they pay the same fees as regular members. Five hundred associates joined in Dublin, which not only gave fullness to the attendance, and increasing interest to the proceedings, but secured $2,500 to the treasury to aid in the va-

rious projects of the search which it is one of the aims of the organization to carry out. President Spottiswoode's address was an elaborate and excellent performance, treating first of the history, influence, and policy, of the Association with which he has long been connected as treasurer, and then taking up the subject of mathematics, which is the specialty he cultivates. His treatment of this subject is highly instructive, and at the present time most opportune. He not only presents very forcibly the general interest and claims of the subject, but he takes up certain curious aspects of it that have recently excited much curiosity and attention, and among these the perplexing topic of the fourth dimension of space. His address in full, together with that of Prof. Newcomb, will appear in the next issue of THE POPULAR SCIENCE MONTHLY SUPPLEMENT.

THE STUDY OF PROTOPLASM.

WE print this month the third and last installment of an introductory essay on the nature and properties of protoplasm, by Dr. Montgomery. The author has made this subject a matter of observation, experiment, and profound reflection, for many years; and his views cannot fail to receive the critical attention of philosophical biologists. Dr. Montgomery is deeply impressed with the immense scientific importance of this comparatively new field of exploration, and we think he does not in the least exaggerate the serious interest of the questions opened by this line of study. Protoplasm is the physical basis of life, and its problems are the initial problems of life. Protoplasm is a living substance endowed with capacities of vital movement, and the question of the origin of life is narrowly and sharply a question of the origin and production of protoplasm. It may never be answered, and many think it would be a dreadful thing if it should be answered. All other mysteries of Nature, they hold, may be properly explored, but to explore and explain this is nothing short of stealing a divine secret. Yet if the mystery can never be cleared up, as they assure us, then surely there is no harm in probing it; while, if it can, the fact itself is proof that it ought to be done, and that no harm will result.

But, whatever may be the final event, Dr. Montgomery has at any rate put the issue in a nice little nutshell. There is a gulf between the organic and the inorganic worlds which we are impressively assured is broader than the Pacific, and can never be fathomed; Dr. Montgomery says that, by the chemical substitution of an atom of hydrogen for an atom of oxygen, it will disappear. He remarks:

"Is not protoplasm a chemical compound like other substances, merely varying from them in its degree of molecular complexity? Its most characteristic manifestation, its distinguishing mode of motion, its peculiar force—the one specific activity constituting its most vital difference—is better known to us than any quality which forms the distinguishing feature between other substances. Do we greatly concern ourselves about the origin of MgO,SO_3+7H_2O, or any other mineral substance? Why, then, should the origin of some combination of C, H, N, O, be made a question of the life and death of our principal philosophies? Has it actually come to this, that the scientific foundation of our creed rests on the decision whether COO is or was once changed into CHO by natural or supernatural means; and this when there is plenty of H about in our world? Yes, it is even so, however incredible, however little flattering to our intellectual pretensions. The contending claims of naturalism and supernaturalism, the fate of the most momentous question touching the guidance of our life, turn actually, in the field of science, upon the paltry issue of the synthesis of ternary carbon-compounds, whether this be chemically or whether it be super-chemically effected. COO is undisputably an inorganic compound. CHO is indisputably an organic compound. This designates accurately the actual depth of the gulf existing between organic and inorganic Nature."

YELLOW FEVER, AND WHAT TO DO ABOUT IT.

THE rapid spread and appalling mortality of the yellow-fever plague in the towns of the Lower Mississippi have profoundly moved the sympathy of the country, and very naturally raised the urgent question as to what shall be done in so fearful an emergency. Governor Bishop, of Ohio, has made a proclamation, calling upon all the Christian people of his State to assemble in their houses of worship at a given date, and offer their united prayers to Almighty God, imploring him to interfere and stop the pestilence. It seems to us an entirely proper thing to appeal to religious feelings on such an occasion as this; but it should be done in such a way as not to evade the lessons they teach, and we trust it will not be thought ungracious if we point out Governor Bishop's presentation of the case as seriously at fault. Moreover, he brings science into the case in a way that is open to objection.

There are different views in regard to the expediency of such public action as Governor Bishop has taken. Many think it does more harm than good, but that depends entirely upon the way it influences human conduct. If reliance upon Divine help, which, it is supposed, can be especially secured by conspicuous demonstrations of public prayer, has the least effect in checking human effort, such action as that of Governor Bishop is injurious. Only when prayer quickens human exertion in such instances as this is it beneficial; if substituted for it, it is ill-judged and detrimental.

This is simply the dictate of commonsense, which enlightened rulers have already acted upon. It is well known that when the Scotch Presbyterians petitioned Lord Palmerston to appoint a day of national prayer, to induce the Almighty to stretch forth his hand and stop an epidemic, his lordship declined to do it, on the rational ground that, until the people had done everything in their power to prevent it, it would be impertinent to call upon Providence to interfere; in other words, they had no warrant to ask him to protect them from the consequences of their own neglect.

The Ohio governor does not proceed upon the sensible view of the British premier. He assumes the incompetency of science and the insufficiency of human effort, both of which he declares to be "unavailing" to arrest the plague; and, these agencies having failed, he proposes, as a last resort, to utilize "the intervention of Almighty God."

But it is not true that human science and human effort have proved unavailing. They have indeed not stopped the yellow fever, but does Governor Bishop assume that they have been thoroughly tried, and accomplished every thing that is humanly possible? But they *have* proved availing and greatly efficient in checking the pestilence and diminishing its fatality; and to deny this is to convict the whole nation of folly in the exertions it has put forth to limit the ravages and mitigate the sufferings of the plague-smitten districts. Yellow fever may not now be wholly preventable, but nobody denies that it is partially so; and nobody knows the degree to which it may be repressed and escaped until far more vigilant, efficient, and comprehensive measures of precaution are resorted to than have yet been undertaken.

But, besides basing his action upon a wrong theory, which is to invoke miraculous intervention, to obtain that which can only be procured by natural means, Governor Bishop's view is, besides, not in the highest sense reverential and religious. He instructs the pious people of his State to ask the Almighty to stop the devastating progress of the plague, as if that progress was not in perfect accordance with providential intentions. To ask the Deity to interfere in this way is to counsel

him to reverse his own plans, and abandon that method of governing the world through the operation of inflexible laws which all truly religious people must regard as the Divine method. Ohio wisdom suggests to Divine Wisdom such a change of policy as, if carried out, would simply turn order into chaos. There may be many things about the providential government of the world that we cannot explain, but it is not difficult to see the large benignity of severe and inexorable punishment for violated laws. In nothing is the sacredness of these ordinances so attested as in the death-penalties that follow their transgression.

Governor Bishop arraigns human science and human effort as having failed to stop the progress of this scourge, and says that now the only hope is God's promise to answer prayer. But has not prayer—fervent, agonizing, soul-rending prayer—been already resorted to day and night in the private closet, and at the family altar, as well as in the places of public devotion, and that, too, all over the land? Yet the epidemic has not been stayed. Why did the governor not rank all this impassioned supplication with the other failures which he offers as reasons for *his own* intervention. And, if he has faith in the efficacy of a State-appointed appeal to Heaven, why did he postpone the demonstration for a week, when hundreds are dying daily?

We are far, as has been already said, from condemning the appeal to religious considerations and influences in an extremity like this, but it should be put on enlightened grounds, and become a means of incitement to nobler action. Prayer is efficacious just in proportion as it reacts upon the supplicant to inspire a higher activity, and in this way it may become a potent agency for moving men in great emergencies. This being the true point of view, in place of the proclamation issued by Governor Bishop, we should have preferred to see something like the following: "Whereas, a plague is desolating various Southern cities, which all means hitherto adopted have failed to arrest, let the devout people of Ohio gather in their several places of worship without delay, and, reverently recognizing the Divine wisdom in this fearful dispensation of suffering, humbly confess their sins of neglect and omission, their ignorance, carelessness, and culpable apathy in regard to all sanitary matters, and their want of quickened sympathy with the afflicted communities, and register solemn vows to Heaven that they will at once enlarge their measures of help to the devastated towns, and will in future be more vigilant and faithful in discharging the religious duty of guarding and promoting private and public health."

COOKERY AND EDUCATION.

We are getting familiar with the closer collocation of these hitherto widely-separated ideas, and their permanent unification in our common thought will constitute an important step of progress in domestic improvement and social amelioration. It will be slow work to connect cookery and education in this country, and attempts to bring about its practical accomplishment will meet with many impediments. Meantime we hail with satisfaction every indication that this desirable result is being attained anywhere. If our English friends are to be the pioneers in this most useful movement, let them have the honor of it. We notice that the following paragraph is going the rounds of the papers:

"Regular instruction in practical cookery is a part of the new system in the public schools of London. In every girls' school in which domestic economy forms part of the school course, one of the teachers is required to give lessons on food and its preparation; and for advanced classes twenty-one kitchens are to be established in different parts of London, each of them fitted with suitable appliances, and to be presided

over by a practical teacher of cookery. This is a comparatively recent innovation, and has only been adopted after a sharp struggle."

Of course no such measure could be adopted except after severe struggle. The time in schools and the ground in education are all occupied, and new subjects are resisted instinctively by those in control of existing schools. The London advocates of the cooking-schools made a strong point by representing that, while the school board was spending a great deal of money for ornamental studies, the knowledge of the arts and interests of common life was dying out among young people. This does not imply that these practical arts have ever had a fair chance in the schools, but that absorption in other subjects stifles even the ordinary interest that would be felt in more useful studies. The difficulty in linking cooking-schools on to the common schools is, that the practice of cookery is not regarded as education, and this is but a part of the old notion that nothing practical or manipulatory is properly education. There was once the same objection to considering practice in the chemical laboratory as truly educational work. That prejudice has been gotten over now; but what is a kitchen but a chemical and physical laboratory where intelligence ought to be developed in connection with practical processes? Culinary changes go according to law as well as transformations of matter anywhere else, and they just as much require cultivated thought to guide them. No doubt a brainless automaton in a kitchen may by long practice and mere imitation acquire a certain successful facility in work, but this has always been the case in all the arts. Mind has come in play and the advancement of other arts to such an extent that to go back now to mere blind, imitative practice would be almost to abolish them. The art of preparing food is still in the empirical condition, and, what is worse, is generally abandoned to a specially ignorant class. We have no sanguine hopes about the renovation of the kitchen by the better teaching of the culinary art, but the work is nevertheless thoroughly begun, and is certainly to go steadily, though perhaps slowly, onward.

LITERARY NOTICES.

INTERNATIONAL SCIENTIFIC SERIES, No. XXIV.

A HISTORY OF THE GROWTH OF THE STEAM-ENGINE. By ROBERT H. THURSTON, A. M., C. E., Professor of Mechanical Engineering in the Stevens Institute of Technology. New York: D. Appleton & Co. Pp. 490. Price, $2.50.

IN the preparation of this work Prof. Thurston has made an important contribution, alike to the excellent series of works of which it will form a part, and to the historical literature of the arts and sciences. There was a niche for such a book, which ought to have been filled before. We have had many works on the steam-engine, from elementary catechisms to ponderous treatises, all of which have given more or less attention to its origin; but there was still wanting a volume that should tell the entertaining story of the growth of this wonderful machine in a way to interest the popular mind without impairing the dignity or diminishing the instructiveness of the narrative. Prof. Thurston may be congratulated on having executed his task in a manner not unworthy the remarkable interest of the subject.

And this, it must be confessed, is saying a good deal, for the steam-engine is unique and incomparable both in its present position of commanding influence, and in the romantic elements of its historical development. It is now the most powerful agency the world possesses for the improvement and extension of civilization, and its noble efficiency in this respect is but a measure of the immense intellectual labor that has been expended in producing it. It was not struck out by the creative genius of any one man, nor constructed by the combined inventive effort of any one age, but it is a product of centuries of mental exertion; and, looking back to its crude beginnings

and tracing the slow stages of its progress, we may take its condition at any time as indicating the progress in man's knowledge of the laws of Nature. It has grown with the growth of science and the advance of the human mind.

It was known thousands of years ago that, when fire is applied to water, vapor is formed that is capable of producing mechanical effects, and centuries before the Christian era attempts had been made to use this force in impelling a machine. The revolving Æolipyle of Hero, the Alexandrian, was a toy for a thousand years. During the middle ages many a mechanical genius played with it, but in vain, for there was no knowledge, and consequently there were no valuable results and no progress.

With the modern awakening of inquiry the subject was pursued by many ingenious experimenters, in different countries and at different times, until at the beginning of the eighteenth century so much had been found out about the properties of heat, water, and air, and so many devices had been hit upon to apply them, that it became possible to combine the different elements into a steam-machine that could perform work. Newcomen's engine of 1705 embodied the ideas and artifices that had been previously gained, and, though very imperfect, was still available for useful mechanical effects. The steam-engine then first became a fact and a success.

From this time onward, to the patenting of Watt's double-acting engine in 1769, was a period of great activity in improving and developing the machine. Scientific research led the way in working out chemical and physical principles, and inventors were busy in perfecting and combining contrivances which were crowned by James Watt, who, by introducing the principles of separate condensation and double-action, gave to the steam-engine its modern form and made it available for innumerable applications.

After Watt's great success we have a hundred years of still further improvements and refinements in the mechanism, and an enormous extension of its uses. From a contrivance supposed to be mainly valuable for pumping water, it became a universal motor equally valuable for manufacture and for locomotion on sea and land.

But, though it has been greatly perfected, the steam-engine is confessedly still imperfect. It has been undergoing steady improvement in recent years, and its theory is now so well understood, through the refined elucidations of physical research, that the pathway of future improvement is clearly discerned by sagacious engineers.

The history of the growth of this remarkable mechanism, that has now become so potent in the operations of human society, has an epic interest of grander meaning than can be found in any history of those destructive spasms in society that are sung and celebrated as war. The steam-engine is a triumph of peace, a victory of the pacific and constructive agencies of civilization, a conquest of Nature through the pursuits of science, and a symbol of the rise of modern industrialism and its successful conflict with the malign military spirit by which the world has been scourged through all the past.

Prof. Thurston has therefore chosen a theme of great interest in writing the history of the steam-engine, and it has not suffered in his hands. He has done admirable justice to its large and varied elements. The principles involved in the mechanism at all its successive stages are analyzed and stated with clearness, and the numerous contrivances and constructions by means of which the steam-engine has been built up and adapted to various ends are plainly, perspicuously, and fully described. The characters, circumstances, and labors, of the great men who have had a share in producing it are pleasantly sketched, and the narrative is enriched by anecdotes and personal episodes that relieve and enliven the more serious discussions of the book. Solidly instructive throughout, it is at the same time most agreeable reading, while many of the narrative parts are spirited and exciting.

Nothing further needs to be said to the readers of THE POPULAR SCIENCE MONTHLY respecting the merits of Prof. Thurston's work, as they are already acquainted with them through portions of it which have appeared in these pages during the past year. One feature of the book, however, deserves especial recognition, and that is the elegance and profusion of its illustrations. In this respect no popular work upon the subject has ever appeared that can at all compare

with it. The woodcuts are in the most finished style of the engraver's art, and have been prepared at a lavish expense. Besides the array of fine woodcuts, illustrating the steam-engine in all its phases, there is a collection of elegant portraits interspersed through the work of all the principal men whose names are associated with its progress. These excellent likenesses cannot fail to heighten the interest that will be felt in the biographical features of the volume.

THE JOURNAL OF PHYSIOLOGY. Edited by Dr. MICHAEL FOSTER, of Cambridge, with the coöperation in England of Professors GAMGEE, RUTHERFORD, and BURDON-SANDERSON, and in the United States of Professors BOWDITCH, MARTIN, and WOOD. London and New York: Macmillan & Co. $5.25 per year.

THIS new project in scientific journalism, though under the responsible control of the eminent English physiologist, Dr. Michael Foster, has nevertheless so international a make-up as to give it a strong claim to liberal American support. Dr. Foster's corps of assistant editors are all very able men; and when we say that the American cooperating editors are Prof. H. P. Bowditch, of Boston, Prof. H. M. Martin, of Baltimore, and Prof. H. C. Wood, of Philadelphia, it will be seen that American science is well represented, so that there will be no excuse if the physiological work of this country is not fairly chronicled. We are glad to see these indications of a growing scientific unity and practical co-working between the two countries. The politicians will continue to nurse antagonisms and alienations in the interest of what they deem patriotism; it remains for Science to undo their work as far as it may by cultivating a policy of harmony and mutual helpfulness.

The Journal of Physiology is to be a record of original research and progress in this branch of science; but its editors give a wide and rational construction to the term "progress" as applied to physiology. While experimental manipulation will remain the fundamental means of getting at facts, it will still be recognized as legitimate to *think* about the facts and find out their *meanings*. The editors say in their announcement:

"The physiologist works not only by experiment, but also by observation, and indeed by what is often depreciatingly spoken of as speculation. The conductors of the *Journal* would be the last to wish that its pages should be occupied by idle writing and the exposition of baseless views; but they would be equally unwilling to refuse a paper because it threw light on a subject by rearranging old facts rather than by bringing forward new ones."

The relations which the periodical will sustain to the medical profession, from which it ought to derive a strong support, are thus indicated:

"No branch of study during recent years has been more fruitful in physiological truths than the investigations into the action on living organisms and tissues of the various chemical bodies known as poisons and drugs. Between such investigations and those into the action of medicines no logical separation is possible, and the physiologist who does not welcome the physiological truths gained by medical practice as warmly as those coming from the laboratory is unworthy of the name. So also a little reflection teaches us that the phenomena of disease are in reality the deeper and more hidden events of the body thrust up to the surface by some dislocation of the economy. Hence all communications, in which the results of pathological observation or experiments are discussed with the view of elucidating their causation rather than in the interests of clinical science, may fairly find a place in a journal devoted to physiology."

As *The Journal of Physiology* will be occupied with substantial original work, and as the supply of this kind of matter is not steady and regular, the issue of its successive parts and the amount of material they contain will be subject to the discretion of the managers. Instead of appearing at strictly regular intervals, the numbers will be issued at periods varying from two to three months, while from four to six numbers will form the annual volume of about five hundred pages. The Germans are falling into this mode of publication, which seems sensible for a periodical of this kind. One of its obvious advantages is, as the editors say:

"That it prevents a discovery made by one man from being forestalled by another, whose observations, although really made later in point of time, might sometimes obtain priority under the ordinary method of publication."

Of the importance of the science of physiology, nothing needs here to be said. A great body of physiological truth has been established which is of such moment to the welfare both of individuals and of the

community at large that the subject ought to have great prominence in education and to be taught to every child at school. But while many physiological principles and facts are so well established that they require to be understood for practical ends, yet the subject is still undergoing rapid development, and new results are being constantly reached which throw further light upon the operations of the vital economy, and are often immediately useful. *The Journal of Physiology*, therefore, has a valid claim upon the attention of many outside of scientific and medical circles. It is such a work as every teacher of physiology, especially in our higher schools, should have at hand, to illustrate the exact state of present knowledge upon numberless questions in relation to which current text-books may be insufficient or behind the times. Where teaching has not become purely mechanical and perfunctory, and all care and conscience have not died out, the teacher of physiology might give freshness and authority to his instructions by subscribing to this new magazine, and making himself familiar with its contents.

AMERICAN JOURNAL OF MATHEMATICS, REAL AND APPLIED. Editor-in-Chief J. J. SYLVESTER, LL. D., F. R. S. Published under the auspices of the Johns Hopkins University. *Second notice.*

THE second number of the *American Journal of Mathematics* reaches us. It is very handsomely printed in quarto, and the formulas look as inviting as formulas can. It undoubtedly belongs to the highest class of mathematical periodicals. We will not presume to pass judgment upon the utility of all those speculations concerning space of four dimensions, the exact movements of the moon, the abstrusities of pure algebra, the phyllotactic numbers, etc. There certainly is such a thing as economy in research; and, fully admitting that each principle of pure mathematics is likely some day to find an application, it is a question to be considered whether it is worth while to spend time upon a theorem a thousand years before it will probably be needed. The principles of compound interest apply as much to brains as to money. If, instead of expending a certain portion of energy upon the resolution of a distantly useful problem, I devote it to something which has immediate applications, an advantage will have been gained which will have its effect through all future time. Here is a little question which we may leave to the mathematicians to solve, if anything so simple can interest them: Suppose that a certain mathematical study is destined to find an application as important as the conic sections have found, but only after a thousand years. What, upon the principles of compound interest, is the present worth of it as compared with that of an equal expenditure of energy in any immediately practical way?

When we call to mind what an army of intellects have devoted themselves to such subjects as, say, the resolution of cubic equations, we can hardly help suspecting that such researches, though of a higher order of activity than chess-playing, are chiefly of value for the amusement they afford. What is really useful is not the solution of this or that problem, but the existence of the mathematician himself. The civilization of our time has been more promoted by engineers, inventors, and popular writers on science, than by almost any other classes of men. But these persons are led by scientific men. The scientific men are certainly led by the physicists, and these in turn by the mathematicians. Thus, notwithstanding the smallness of the class who read mathematics, the influence of the great geometers spreads in concentric circles, until there is no one, not even the common day-laborer, who is not better off for it. It is not necessary that the problems in which the mathematicians most delight should be particularly useful. It is not necessary that the most profound minds, whose real value to civilization is the greatest of all, should ever concern themselves with the applications of mathematics. Their business is especially to work out fruitful conceptions, and to impress them upon other minds; and this they do not only by their writings, but also by their personal conversation.

The truth is, that productive industry only builds the substructure upon which civilization rests. The fairy palace itself is due to the pursuit of pleasure, to luxury, to the doing of useless things. Every amusement tends toward corruption, but every one tends also toward culture. An amuse-

ment is more or less beneficial according as one or other effect predominates in it.

Mathematics may be loved by a sybarite, but it will never be his occupation. Yet it is a most gentlemanly amusement, pursued far from vulgar passions and applause, in the calm of a library, nothing sordid mingling with it. Those harsh and crabbed formulas which fill us outsiders with such dismay, and from which we flee in terror, doubtless become, after a while, to the devotee as musical as is Apollo's lute, and are regarded by him as affectionately as a chess-player regards his finely-carved queens and castles.

Everybody, of course, knows that the practical utility, not to say necessity, even of the highest mathematics, is immense. But we have preferred to consider it in relation to the purely theoretical or very remotely practical departments which will no doubt occupy a large portion of the *American Journal of Mathematics*. Even so considered, the present mathematical revival which the coming of Mr. Sylvester has occasioned, and the establishment of this journal, may be characterized as important events for the highest welfare of the country—important even for its material welfare. It is not to be expected that the actual readers of such a journal should be very numerous, and, though subscriptions will be drawn from Europe, yet the success of it must depend upon its finding subscribers who do not read it, but who appreciate its value. Whether a sufficient class exists in America which understands the importance of intellectual activity of the profoundest kind to enable such activity to exist here, is a vital question for our destiny.

Not to close this notice without a bit of criticism, we may mention that one of the editors of the *Journal* has by means of a "Crelle's Table" found in a few minutes that the number 191,071 is either a prime or else divisible by a factor less than 137. This is pronounced by another of the editors to be "a real stroke of genius." We should like to have the glory of it a little further elucidated. We have put Crelle's Table into the hands of a computer, and requested him to find the divisors of the number in question. Having no pretensions to genius, he did not stop at 137, but, proceeding in the ordinary humdrum way, announced absolutely, in a quarter of an hour, that the number was prime. We confidently look for an article in the coming number setting out and explaining the wonderful stroke of genius in question, the marvel of which does not seem to have lain in its reaching a very speedy or complete solution of the problem undertaken.

DEMOCRACY IN EUROPE: A HISTORY. By Sir THOMAS ERSKINE MAY. New York: W. J. Widdleton. 1878. 2 vols.

In an appropriate introductory essay to this work the author sets forth the principles that constitute its foundation. It can scarcely be said that he offers anything new here; he, however, points out truths that can never be too sedulously insisted upon. After stating that by democracy he understands "the political power or influence of the people under all forms of government," that "it denotes a principle or force and not simply an institution," he discusses the moral, social, and physical causes of freedom, supporting his assertions, the while, with historical instances. He next shows that, as the constant development of popular power is the result of the intellectual and material progress of a nation, it must be accepted as a natural law; and that, instead of striving to breast the current, statesmen should endeavor to urge it forward in the most advisable channels. As a matter of course, the author has not avoided the opportunity of commenting upon the excesses of democratic ideas, and of breaking lances with devotees of communism and socialism.

Sir Erskine May enters the historical field with a gloomy portraiture of the constitutions of the old Eastern nations, and, in order to show that freedom is a growth wholly peculiar to European soil, he endeavors to prove that in all times—even the present—the main characteristics of Eastern society have been immutability and immobility. He begins with an examination of the constitution of India, and claims that the Hindoos have never known freedom; that their ignorance has been opposed to it; that their enslavement has fostered their ignorance; and concludes that "England has already given more 'liberty' to India than ever she aspired to under her former rulers." In the histories of Persia, China, Japan,

Phœnicia, Carthage, and Egypt, the author likewise fails to discover germs of democratic ideas. It will not be amiss for us to state that Von Schlegel, Ferrari, and the more distinguished modern critics, have agreed that the East, too, has been always progressing, steadily if slowly, in the path of civilization, and that at no period was democracy entirely unknown in Eastern countries; the village communities of India, old as the nation itself, bear witness to this assertion.

Chapters II.–VI. are devoted to Greece and Rome. An attempt to go over the whole of his ground with the author would be a trespass upon the limits of this notice. We can only refer the reader to the work itself, where, among many absurd theories and startling declarations, he may nevertheless find many good ideas.

We cannot, we are sorry to say, so recommend that portion of the work which treats of the fortunes of democracy during the middle ages. Like the older writers who had not comprehended the philosophy of history, Sir Erskine May persists in calling this epoch by the now exploded title of "the dark ages," and seems to see in it nothing beyond vandalism and ruins. In love with "the old world," he has failed to realize its shortcomings, and accordingly the necessity of demolishing it in order to rebuild with the old materials one more in keeping with democratic ideas. He is forced, however, later on, to acknowledge that "this general prostration of the people of Europe was gradually lessened by the operation of several causes, which contributed to the ultimate regeneration of society and the advancement of freedom. These causes are to be sought in the 'free' institutions of the conquerors themselves, in the traditional laws and customs of Rome, in the influence of Christianity and the Catholic Church, and in the increasing enlightenment and general expansion of mediæval society." Here he presents the Church as the protector of the people's rights, and as counteracting the absolutism of kings and barons, and therefore as a democratic institution; afterward he notices the Church as directly antagonistic to freedom, and in the end hits upon the truth by saying: "Any pretensions of the Church which impaired the absolutism of rulers were so far favorable to liberty; but the pope was contending for ecclesiastical domination, not for civil freedom; and, if the latter cause sometimes profited by his intervention, it was because kings were weakened—not because the Church was the apostle of liberty." As he proceeds, our author shows how the cause of democracy was gradually helped along by the growing refinement of the barons, by minstrelsy, chivalry, and the crusades; which, "by weakening the aristocracy, increased on one side the power of the monarchs and on the other the freedom of the people," and led to the enfranchisement of the rising communes, to the revival of towns and the growth of municipal liberties; how all this brought about a revival of learning, an impulse of new life in the universities, to which was due the development later on of the liberty of thought and the Reformation.

Resuming his way backward, Sir Erskine May devotes the seventh chapter to the Italian republics, and, in presenting their history, shows how several causes, foremost among them being the earlier intellectual revival, operated to bring about an early development of municipal liberties in Italy. He explains how feudalism never firmly took root in Italy; how, after Charlemagne, the weakness of its kings favored the political power of the cities; how the fusion of the sturdy northern races with the Italians similarly assisted the assertion of popular rights; how a comparatively equal distribution of lands contributed toward social and political equality; how from all these varying causes no less than two hundred free municipalities or republics arose in this fair land, in which, in short, democracy attained to an unprecedented development. But here, we are afraid, the author has over-estimated this "freedom" of the Italian republics, each of which aimed at liberty only for itself—each party in every city determining upon the exclusion of its rivals from the enjoyment of all franchises. He concludes with a comparison of the Italian republics with one another, and with the old republics of Greece, and surveys, briefly and accurately, the causes that led to Italy's enslavement and its regeneration in our own day.

Next follows a review of the history of Switzerland, which offers one of the most

interesting examples of the purest and simplest democracy and of well-contrived and enduring republican institutions to be found in the annals of Europe. The two chapters on this country are, perhaps, the most praiseworthy in the whole book; Calvin is judged without fanaticism, if we overlook the too great importance attributed to his reforms in connection with the freedom and democracy of the country.

The progress of democracy in the Netherlands is followed up in the first two chapters of the second volume. "Two aspects of democracy," says the author, "are here illustrated, the growth and political power of municipal institutions and the assertion of civil and religious liberty." He delineates the first of these aspects by recounting the civil history of the Netherlands up to the reign of Charles V.; the second aspect is developed in the description of the bloody measures adopted by Charles V. and Philip II. of Spain to crush out the growing spirit of the Reformation, and in the subsequent struggles of these countries for political independence. The career of William of Orange, the shrewdness and bravery he opposed to craftiness and revolting barbarity, the fruitless attempts of the persecutors to corrupt him, and the finally successful attempt to assassinate this apostle of civil and religious liberty—these are necessarily interwoven into the story of the struggle for the rights of conscience—the first and most memorable of the kind in the world's history. After dwelling at length on the share of freedom afterward enjoyed by the Low Countries, and the subsequent decline of their fortunes, he closes with a short notice of ultramontanism in Belgium and of the contemporary prosperity of that country and Holland.

REPORT ON FORESTRY. By F. B. HOUGH. Washington: Government Printing-Office. Pp. 650. ECONOMIC TREE-PLANTING. By B. G. NORTHROP. From "Report of the Secretary of the Connecticut State Board of Agriculture." Pp. 29.

DR. HOUGH'S industry in collecting the materials of this "Report" is worthy of all praise; not less so is the intelligent use which he makes of them. The volume is indeed a storehouse of facts relating to forestry, and the information which it contains is of very great practical importance. The destruction of forests brings about great climatal changes, and the history of Spain and other countries shows how regions that once were fruitful have been changed into barren deserts by the reckless clearing of woodland. The time has come for taking concerted action toward "reforestation" in the United States. Dr. Hough considers in detail many of the problems which present themselves for solution—as the comparative advantages of *sowing* and *planting*, the proper number of trees to an acre, the adaptedness of different species to different localities, etc.; and Mr. Northrop goes over much of the same ground, though of course less fully, and with especial reference to the needs of the State of Connecticut. On these and sundry other points Dr. Hough quotes the experience of practical and scientific men, giving in full many documents of the highest value. Then follow statistical tables showing the consumption of wood in different industries, for household uses, railroads, etc. The relations between forests and climate are discussed *in extenso*, and Becquerel's "Memoir" on that subject is given in full. A sketch of the "Schools of Forestry" in various European countries is given, with a view to suggest hints for the guidance of forest-conservators in the United States. We recommend both of these publications to the earnest attention of our readers.

A NEW CYCLOPÆDIA OF CHEMISTRY, Theoretical, Practical, and Analytical, as applied to the Arts and Manufactures. By Writers of Eminence, on the Basis of the Late Dr. Muspratt's Work. Illustrated with numerous Woodcuts and Steel-Plate Engravings. Philadelphia: Lippincott & Co. 50 cts. per number.

THIS comprehensive and valuable work, which is announced to consist of forty parts, has now reached the thirty-fifth part, and its completion may therefore be soon expected. The work has been executed with care and ability, and we have found it useful and satisfactory for habitual reference on the extensive and important subjects of chemical manufacture. Its illustrations are numerous and elaborate, the text clear and attractive, and the treatment of subjects full, copious, and trustworthy.

PHYSICS OF THE INFECTIOUS DISEASES. Comprehending a Discussion of Certain Physical Phenomena in Connection with the Acute Infectious Diseases. By C. A. LOGAN, M. D. Chicago: Jansen, McClurg & Co. Pp. 212. Price, $1.50.

THE author of this work spent four years on the west coast of South America, a region remarkable for two things: 1. Certain peculiar physical features and aspects; and, 2. A marked exemption from infectious diseases. He assumes a connection between these two facts, and has aimed to trace it out, and to derive important medical conclusions from the results. The problem of the influence of physical conditions upon health and disease is fundamental but at present obscure, and, while its investigation is of the greatest moment, advanced conclusions built upon it must be received with caution. The volume is instructive, and opens a special inquiry, which will no doubt be followed up by medical observers.

A SCIENCE PRIMER; ON THE NATURE OF THINGS. By JOHN G. MACVICKAR, D. D. Edinburgh: Blackwood & Sons. Pp. 112.

THIS little book may claim the position of distinguished preëminence in absurdity among the mass of absurd publications with which we have been lately deluged, under the title of "Science Primers." We by no means intimate that those little books are without merit, but as rudimentary treatises, as books for beginners, as primers, they are with hardly an exception ridiculous. He who writes a primer of science should know two things—the subject he deals with, and the state of mind to which such a book is addressed. It matters nothing how sound and careful and accurate and trustworthy the writer's statement may be in itself; if it is not adapted to the mental condition of those ignorant of the subject, it will be a senseless and stupid failure. Our science primers are nearly all of this kind. They are written by men who seem to have not the slightest notion of what is needed for the minds of the young, and are in fact addressed to adult minds, and for these they are generally instructive and valuable.

Dr. MacVickar's "Science Primer on the Nature of Things," we might almost suppose, had been written as a burlesque on this class of books. It deals throughout with the most profound and abstract subjects, with remote and contested questions of cosmical science, with knotty problems of theology, and with speculations on chemism, ethers, and the geometrical constitution of molecules. The writer seems, indeed, to be not unconscious of the absurd misappropriateness of his work, and excuses it on the plea that all science is a good deal of a humbug. He says in his preface: "It may, indeed, be alleged that these primers present to their readers merely a smattering of science. But may it not with truth be replied, in similar terms, that the actual science of the day, in all its details, when viewed in reference to a satisfactory view of Nature and its economy, is itself merely a smattering?"

PUTNAM'S ART HAND-BOOKS. Edited by Susan M. Carter, Superintendent of the Woman's Art School, Cooper Union. I. The Art of Sketching from Nature. By THOMAS ROWBOTHAM. 27 Illustrations. Pp. 74. Price, 50 cents. II. The Art of Landscape-Painting in Oil-Colors. By W. WILLIAMS. Pp. 74. Price, 50 cents.

THESE neat little hand-books, which have gone through many editions in England, are now reprinted for the use of American art-students, and are to be soon followed by others on "Flower-Painting," "Figure-Drawing," and "An Artistic Treatise on the Human Figure." They seem to be prepared by experienced artists, and the name of the editor is a guarantee that they will prove useful to the cultivators of practical art in this country.

THE PRINCIPLES OF LIGHT AND COLOR. Including among other Things the Harmonic Laws of the Universe, the Etherio-Atomic Philosophy of Force, Chromo-Chemistry, Chromo-Therapeutics, and the General Philosophy of the Fine Forces, together with Numerous Discoveries and Practical Applications. Illustrated by 204 Exquisite Photo-Engravings, besides Four Superb Colored Plates printed on Seven Plates each. By EDWIN D. BABBITT. Science Hall, New York: Babbitt & Co. Pp. 560. Price, $4.

THIS is an elaborate and elegantly illustrated volume which we have not yet had time to read. The writer is a bold speculator, and seems to differ very widely and

profoundly from the accredited expositors of physical, chemical, biological, and psychological science. He has a new philosophy of molecules and ethers, and the inner nature of things, interprets the large phenomena of the universe in his own way and includes magnetism, clairvoyance, psychic force, odic force, chromo-mentalism, chromo-therapeutics, and many other curious things, in his conception of Nature, and claims to educe their laws from "the etherio-atomic philosophy of force." The writer has bestowed a vast amount of labor upon his work, and, whatever amount of truth it will be ultimately found to contain, it will meet the wants of many, and be read with satisfaction by those interested in its peculiar topics and its author's independent treatment of them.

THE NATIVE FLOWERS AND FERNS OF THE UNITED STATES. By THOMAS MEEHAN. Parts III., IV., V. Boston: Prang & Co.

THE interest of this work is well sustained in its recent numbers. The colored illustrations are beautifully life-like, and the accompanying text interesting, and prepared with excellent judgment as to what a popular work requires. We cordially renew the commendation passed upon this worthy enterprise upon the appearance of its earlier numbers.

SCIENCE LECTURES AT SOUTH KENSINGTON. New York: Macmillan & Co. Vol. I. Pp. 290. Price, $1.75.

THIS is the first installment of a valuable series of expositions upon chemical and physical subjects, on the whole popular, and all thorough and trustworthy. It contains lectures by Captain Abney on "Photography;" by Prof. Stokes on "The Absorption of Light and the Colors of Natural Bodies," and on "Fluorescence;" by Prof. Kennedy on "The Kinematics of Machinery;" by F. J. Bramwell on the "Steam-Engine;" by Prof. Forbes on "Radiation;" by H. C. Sorby on "Microscopes;" by J. T. Bottomly on "Electrometers;" by S. H. Vines on the "Apparatus relating to Vegetable Physiology," and by Prof. Carey Foster on "Electrical Measurements." The subjects are interesting, the authorities are good, and the lectures valuable.

HOW TO TAKE CARE OF OUR EYES. With Advice to Parents and Teachers in regard to the Management of the Eyes of Children. By HENRY C. ANGELL, M. D. Boston: Roberts Brothers. Pp. 70. Price, 50 cents.

THE neglect, exposure, and abuse of the eyes in recent times, from many causes and in many ways, have become so great an evil as to call forth many books on the care of vision and the hygiene of the eye. Dr. Angell's contribution to the subject has the merit of being very clear in style, with but a sparing use of technical terms, while it is also condensed, and furnished at a low price. It is full of useful suggestions, which, if followed, would prevent a great deal of the annoyance and suffering that arise from misuse of the eyes.

SHORT STUDIES OF GREAT LAWYERS. By IRVING BROWN. Published by the *Albany Law Journal*. Pp. 382. Price, $2.

THIS volume contains upward of twenty sketches of the most eminent English and American lawyers from Coke to Choate. The notices originally appeared in the *Albany Law Journal*, where they attracted so much attention that the author has been induced to issue them in a collected and separate form. They are not designed as biographies so much as estimates of character and career, yet they contain a good deal of personal incident and delineation, which make the sketches anything but dull reading. As lawyers are always interesting objects to contemplate, good lives of lawyers are always interesting books.

THE DANCE OF DEATH. By WILLIAM HERMAN. New York: American News Company. Pp. 131.

A VEHEMENT denunciation of the immorality of waltzing.

PUBLICATIONS RECEIVED.

Elements of Sidereal Astronomy. By Jacob Ennis. Philadelphia: Collins print, 705 Jayne Street. 1878. Pp. 7.

American College Directory and Universal Catalogue. Vol. II. (1878). St. Louis: C. H. Evans & Co. Pp. 110. Sent free on receipt of 10 cents postage.

Iowa Weather Report for 1877. By Dr. Gustavus Hinrichs. Iowa City, Iowa. Pp. 70.

Proceedings at the Eleventh Annual Meeting

of the Free Religious Association. Boston: 1878. Pp. 90. 40 cents.

Report of the New Jersey State Commission on a Plan for the Encouragement of Manufactures of Ornamental and Textile Fabrics. Trenton: Naar, Day & Naar print. 1878. Pp. 90.

Proportional Representation. By John H. Ward. Louisville: *Courier-Journal*, printers. 1878. Pp. 26.

Native Flowers and Ferns of the United States. By Thomas Meehan. Boston: Prang & Co. Parts 6, 7 and 8. 1878. 50 cents each.

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POPULAR MISCELLANY.

Systematic Promotion of Research.—Prof. R. H. Thurston, Vice-President of the American Association, chose as the subject of his address to Section A, "The Science of the Advancement of Science." Having asked, "Why is the advancement of science to-day so apparently difficult and irregular and toilsome?" he attributed this state of things to the lack of systematic encouragement of scientific studies. The right men, he said, in substance, have never been sought out, and trained for this work. Men of science themselves have chosen rather to pursue their own favorite lines of research instead of investigating in the directions which would yield the best results. The endowment of research has not been urged with sufficient persistence. The materials and the apparatus placed in the hands of men of science for the prosecution of their labors have been too incomplete to permit the most effective application of their efforts. For these and other reasons we are not to-day, as we have not been in the past, prepared to do all that we should in the advancement of science and of the arts. By what practical measures, then, is scientific research to be promoted? The "science of the advancement of science" dictates that we shall seek:

1. To determine what are the most promising and most important directions of exploration in the great universe of the knowable.

2. That we shall endeavor to find young men fitted to become successful observers, discoverers, and philosophers; aid them to gain positions in which their talents may have full scope, and assist to make useful the results of their labor.

3. That we make it a part of our work to obtain for these investigators the means

of research and the material aid which are necessitated by the rapid and ever-accelerating advances of knowledge for which we are indebted to them; to secure the endowment of new schools of science, the more complete organization of older schools, and liberal provision of apparatus and material for every investigator.

4. That we seek to improve our methods of instruction in science, to introduce into our educational systems a better scientific curriculum and far more extended courses, both of pure and of applied science, and to make the position of a teacher of science, viewed from the world's standpoint, a far more desirable one than it has yet become.

5. To make the organization and the operation of our academies of science, and of our societies for the advancement of science, far more thoroughly effective.

6. To endeavor to exhibit to both classes the fact that there exists between the man of science and the man of business a community of interests; the fact that he who accumulates wealth is largely indebted for his success to him who is unselfishly revealing to him the laws by which wealth is increased and business prosperity secured.

Proposed Silk-School Farm.—Certain capitalists in Philadelphia have signified their approval of plans of a silk-school, farm, and village, proposed by Mr. Samuel Chamberlain, and a company is to be formed for the purpose of putting the project into execution at an early day. In a communication to the *Polytechnic Review*, Mr. Chamberlain writes that the plans provide for legal interest on the investment, independently of the silk produced. They provide for a return of the capital by means of improved real estate, and for a profit beyond legal interest by retaining intermediate sections of the land, which, it is expected, will later be sold at a great advance, in consequence of the improvements. They provide growers of trees, silk-worm eggs, and silk, in addition to those to be produced by the school, namely, the renters of forty cottages, each surrounded by an acre of mulberry-trees. They provide cottage culturers, and in a few years teachers of cottage culture, who will show by precept and example how silk may be raised in the midst of family duties. The danger of strikes is obviated by the fact that the renter of a cottage may in the end be an owner, and thus become directly interested in the uninterrupted progress of the work. In the school young persons will be trained to those habits of care, patience, and watchful attention, which are necessary for the successful raising and reeling of silk. The work is light and easy, and, when skill is acquired early, is highly profitable. It is peculiarly suitable for the deaf and dumb, whose misfortune cuts them off from so many occupations. When one such school shall have shown the way, like establishments will arise in many places; and in this way it is hoped to help in turning back into the country the tide of population now flowing into our cities. The failure to introduce silk-culture in 1840 was chiefly due to want of perseverance. The three years of actual trial were not enough to carry it on to success. But a school, farm, and village, whose continuance will be maintained sixteen to twenty years, will secure a permanent source of knowledge, example, and instruction, from which the culture will extend year by year.

Water for Domestic Uses.—The question of pure water-supply has been taken up for discussion by the London Society of Arts, and circulars have been sent out to civil engineers, sanitary officers, and other persons whose callings would appear to make them familiar with the conditions of the problem, inviting from them suggestions and plans for insuring to the whole population of England a sufficiency of pure water for domestic uses. A "Congress," too, has met in London, at which a number of papers, prepared by some of the most competent engineers and sanitarians, were read. In one of these papers, written by Mr. Samuel C. Homersham, the qualities of water fit for domestic uses are stated as follows: 1. Such water should be wholesome, free from animalcules or other organisms, animal or vegetable, either living or dead, and at no time or season of the year, or in periods of epidemics, liable to propagate disease or cause the death of those who drink it. 2. It should be soft and pleasant to use with soap both for washing the person and clothes, for baths and other detergent

purposes, and of a quality such as would not dissolve lead, or form a deposit when boiled. 3. It should be clear and bright, agreeable to the eye, and refreshing to the taste. 4. It should be well aërated, of a nearly uniform normal temperature, and not like river or surface water, unduly warm in summer and unduly cold in winter. All that is needed, in the opinion of Mr. Homersham, and most of the other authors of papers, to insure abundance of such pure water, is that public opinion be educated to insist upon it. Works adequate to provide a regular supply of wholesome water, whether for towns or for small groups of dwellings in the country, might be constructed at moderate expense.

How Teleological Ideas are acquired.—In the course of his able address on "Education a Succession of Experiences," Prof. Grote, Vice-President of the Natural History Section of the American Association, remarks as follows upon the futility of teleological arguments: "From the imperfection and limitation of our senses comes not only a succession of experiences which are incomplete, but a general concept with regard to external matters, which must be of necessity misleading. We are here but a short time, and see little of the outcome of passing events, and can know nothing of the outcome of the world itself. Thus it has come to pass that what we have not fully observed we have assigned to an unknown cause. We have fitted Nature into our own measure, directly led thereto by the imperfection of our knowledge, and we have arrived at the concept that design exists in the world about us as it is displayed in our own handiwork and the work of animals, which, with ourselves, exhibit design in their operations. But in reality what we see in the details of the structure of animals and plants is not design, but adaptation. Suppose we leave a coat in a closet, and while it is there it is visited by a female clothes-moth, which deposits thereon numerous eggs. The little worms hatched from the eggs would at once commence to make free with the nap, and eat holes in the coat with a good appetite. If they ever thought about the matter, would they not conclude that the coat was hung there for their special benefit? They would do so merely because the coat was there. The fact that they adapted it to their own use would be construed by them into a belief that it was designed for their benefit. They would inevitably regard the owner of the coat, could they arrive at this conception, as their benefactor and the preserver of the whole race of maggots. They would know nothing of the thousands of clothes-worm eggs that perish because they never get anything to eat. The fact that life is sacrificed by the wholesale in Nature tells against the argument of design. And Nature is as careless of the species as of the individual. In the crust of the earth are contained the remains of millions of types of form of which Nature has not been careful, but has crushed them out, because they could not adapt themselves to the changing conditions which surrounded them."

Is the Evolution Theory atheistic?—Prof. Simon Newcomb's address, on his retiring from the annual presidency of the American Association, is a singularly lucid exposition of the state of the case as between the *teleological* and the *mechanical* explanations of the operations of Nature. The drift of his argument is best seen in the summary with which the address concludes, and which is in substance as follows: First, when men study the operations of the world around them, they find some of these plainly determined by law, while others appear to be purely arbitrary. This latter class of operations men attribute to the direct action of supernatural beings, gods; and they further ascribe to these gods aims, designs, to be attained through these interventions in the course of Nature. Further, men believe themselves able to discern these designs, and thus to explain these arbitrary operations. But, as knowledge advances, one after another of these operations is found to be really determined by law. Final causes having thus, one by one, disappeared from every thicket which has been fully explored, the question arises whether they now have or ever had any existence at all. On the one hand it may be claimed that it is unphilosophical to believe in them when they have been sought in vain in every corner into which light can penetrate. On the other hand, we have the difficulty of accounting

for those very laws by which we find the course of Nature to be determined. Take the law of hereditary descent: how did such a law, or rather, how did such a process, first commence? If this is not as legitimate a subject for inquiry as the question how came the hand, the eye, or the first germ, into existence, it is only because it seems more difficult to investigate. When the doctrine of the universality of natural law is carried so far as to include the genesis of living beings and the adaptations to external circumstances which we see in their organs and their structure, it is often pronounced to be atheistic. Whether this judgment is or is not correct, Prof. Newcomb would not undertake to decide, but said that it is very easy to propound the test question by which its correctness is to be determined: "Is the general doctrine of causes acting in apparently blind obedience to invariable law in itself atheistic?" If it is, then the whole progress of our knowledge of Nature has been in this direction, for it has consisted in reducing the operations of Nature to such blind obedience. If the doctrine is not atheistic, then there is nothing atheistic in any phase of the theory of evolution, for this consists solely in accounting for certain processes by natural laws.

A New Calculating-Machine.—Mention is made, in the presidential address of Mr. Spottiswoode to the British Association, of a calculating-machine, devised by Prof. James Thomson, which for simplicity of construction compares favorably even with Edison's phonograph. The description given of this ingenious instrument is extremely meagre and insufficient, and does not give any notion of its *modus operandi*. "By means of the mere friction of a disk, a cylinder, and a ball," says Mr. Spottiswoode, "this machine is capable of effecting a variety of complicated calculations which occur in the highest application of mathematics to physical problems. By its aid it seems that an unskilled laborer may, in a given time, perform the work of ten skilled arithmeticians." It is applicable to the calculation of all sorts of periodic phenomena—as those of the tides, and of magnetic and meteorological variations. It will solve differential equations of the second, and perhaps even of higher orders. And through the same invention the problem of finding the free motions of any number of mutually-attracting particles, unrestricted by any of the approximate suppositions required in the treatment of the lunar and planetary theories, is reduced to the simple process of turning a crank.

Grass and Straw as Domestic Fuel.—The Mennonites, who, for a few years past, have been immigrating to our Western and Northwestern States and Territories from the Russian Empire, have introduced into their new homes the "grass-burner stove," by means of which their houses are warmed in winter, and all their cooking done throughout the year. The grass-burner is destined to be generally adopted by settlers in regions destitute of coal or timber, since by its use straw and dried prairie-grass are made to serve as perfectly satisfactory fuel. A description of this peculiar stove, with illustrations, is given by Prof. J. D. Butler, in the *Gardener's Monthly*, from which we copy the following notes on its construction and performance: The material is unimportant; some use brick, others stone, while still others prefer a mixture of sand and clay. The size is considerable, not unfrequently five feet in length, six in height, and two and one-half in width. The stove is erected as centrally as may be in a dwelling, so as to heat all the rooms as far as possible. The structure may be said to have six stories, viz., first, the ash-box; second, fire-box; third, cooking-oven; fourth, smoke-passage; fifth, hot-air chamber; sixth, smoke-passage to chimney or to a drum in an upper room. The fuel-box is about four feet long, and in width and height a foot and one-half. The grass or straw is thrust in with a fork. The author says that, in the house of Bishop Peters, the grass or straw is pitched into the fire-box of the stove for about twenty minutes twice or at most three times in twenty-four hours; that amount of firing-up suffices amply for cooking and heating in the climate of Nebraska. It now remains for American ingenuity to improve on this Russian contrivance—to make it simpler, smaller, cheaper, of better materials, of more elegant design, and of more economical combustion.

How Mountains are made.—In a paper by Prof. Joseph Le Conte, read before the National Academy of Sciences in April, and since published in the *American Journal of Science*, the formation of mountains is explained by the action of horizontal pressure resulting from interior contraction of the earth. The author considers all the principal types of mountain-structure, and appears to account for them very satisfactorily by this theory of horizontal pressure. It would be impossible, within the limits of a Miscellany article, to give an intelligible outline of the entire argument, and we must content ourselves with a synopsis of the author's remarks on the formation of *mountains of a single anticlinal fold*—the simplest conceivable mountain-structure. Here

FIG. 1.—IDEAL SECTION OF SIMPLE ANTICLINAL FOLD (UNSYMMETRICAL).

the deeper strata are thickened and swelled upward by the horizontal pressure, while the upper strata are raised into a vault with little or no thickening, or may even be thinned and broken by tension. The vault is nearly always unsymmetrical, the yielding being greater on one side than on the other. In such cases a great fissure and slip is apt to occur on the steeper side, as shown in Fig. 2. Perhaps the best illustration of a

FIG. 2.—The same, with the strata fissured and faulted.

range of mountains of this simple type is the Uintah Mountains. A cross-section of this range shows a prodigious fault of 20,000 feet on the northern or steeper side of the original fold. If the crust of the uprising region be *extremely* rigid, the vault, instead of being forty or fifty miles across, as in the Uintah Mountains, may be one hundred or several hundred miles across; we have then a *great plateau*. And since an arch of such span, whether filled or not beneath with fused or semi-fused matter, cannot sustain itself, such elevated plateaus are peculiarly liable to *fissure* by breaking down of the arch, and to *slips* by gravitative adjustment of the broken parts. The result is conspicuous escarpments or conspicuous mountain-ridges in the general direction of the axis of the plateau. Such, according to the author, is the origin of the north and south escarpments of the plateau-region of the Colorado, described by Powell, and of the north and south monoclinal ridges in the Basin-region, described by Gilbert and Howell. Again, a monoclinal fold may be modified by *metamorphism*. This, says the author, is especially apt to be the case if the strata be *very thick* and the fold *narrow and high*; that is, if the compression in a given space, and therefore the *heat* of compression, be very great. If, now, such a sharp fold, metamorphosed in its deeper strata along the line of greatest compression, be subjected to profound erosion, it forms a common type of mountain, viz., one consisting of a highly-metamorphic axis, flanked on either side by tilted strata corresponding to each other.

The Differences between Atlantic and Pacific Forests.—The differences between the Atlantic and Pacific forests of the United States are very striking in many respects. Prof. Asa Gray, in a recent lecture, presents a long list of Atlantic forest-trees that are either not at all or but feebly represented on the Pacific slope. For instance, the Pacific forest has no magnolias, no tulip-tree, no papaw, no linden or basswood, and is very poor in maples; no locust-trees, nor any leguminous tree; no cherry-tree large enough for a timber-tree; no gum-trees, nor sorrel-tree, nor kalmia; no persimmon; not a holly; only one ash that may be called a timber-tree; no catalpa, or sassafras; not a single elm nor hackberry; not a mulberry, nor planer-tree, nor maclura; not a hickory nor a beech, nor a true chestnut nor a hornbeam; barely one birch-tree, and that only far north, where the differences are less striking. As to coniferous trees, however, the only missing type is our bald cypress, the so-called cypress of our Southern swamps. "But as to our ordinary

trees," writes the author, "if you ask what takes the place in Oregon and California of all these missing kinds which are familiar on our side of the continent, I must answer, nothing or nearly nothing. There is the madroña (arbutus) instead of our kalmia (both really trees in some places); and there is the California laurel instead of our Southern red bay-tree. Nor in any of the genera common to the two does the Pacific forest equal the Atlantic in species. It has not half as many maples, nor ashes, nor poplars, nor walnuts, nor birches, and those it has are of smaller size and inferior quality; it has not one-half as many oaks; and these and the ashes are of so inferior economical value that (as we are told) a passable wagon-wheel cannot be made of California wood, nor a really good one in Oregon." He then states that, whereas the Atlantic forests contain sixty-six genera and one hundred and fifty-five species, the Pacific has only thirty-one genera and seventy-eight species.

Artificial Cold in the Treatment of Yellow Fever.—Dr. Bushrod W. James proposes, in the Philadelphia *Ledger*, a method of treating yellow-fever patients by artificial cold. He would have in every quarantine-station a ward or room capable of holding several patients, and so arranged that ventilation can be effected solely through ventilators and by means of small anterooms with spring-doors. There must be no entrance or exit to the ward save through the anteroom. The anteroom should be kept at the same low temperature as, or even lower than that in the ward, so that the temperature in the latter may not be raised by the opening and closing of doors by the attendants, nor any of the disease-producing germs escape before they are thoroughly subjected to the low temperature and destroyed. The ward and anteroom must be kept at a temperature not higher than 25° Fahr., the patients being made comfortable by a sufficient amount of bedclothing; and everything that goes from the room, such as clothing, excretions, all emanations, etc., must be exposed a sufficient length of time to the cold. This will kill the poisonous germs, or reproducing cause, and prevent, as far as the cases under treatment are concerned, any risk of the disease spreading. If patients cannot bear so much cold during treatment, an adjoining warmer room can be made, with no mode of access or ventilation except through the cold room, and everything going out of the warmer room must be allowed to remain a sufficient length of time to get rid of the contagion. If no attendant occupies the anteroom, the degree of cold can be kept near zero, in order the more quickly to destroy all the disease-producing agencies.

A Drought-Proof Fodder-Plant.—In a paper on the progress of agriculture in Natal, South Africa, Dr. P. M. Sutherland, surveyor-general of that colony, speaks of the advantages possessed by the Caucasian prickly comfrey (*Symphytum asperrimum*) as a fodder-plant, in regions characterized by annually-recurring seasons of drought. His remarks will doubtless be of interest to farmers settled in some of our States and Territories where like meteorological conditions exist. The plant named is allied to the borage, is a native of the mountainous regions of Circassia, and has long been used as forage both in that country and in Russia. Its original home is at a height of 4,000 feet above the sea, but it thrives well in a great diversity of climates, and bears hot and dry seasons with impunity, on account of the depth to which its strong root penetrates into the ground. There are two varieties of the plant, one with a hollow and the other with a solid stem. The latter is an excellent food for stock of all kinds; especially does it increase the quantity and improve the quality of cows' milk. It grows with marvelous rapidity and luxuriance. Land which yields eight tons of grass per acre gives from sixty to a hundred and fifty tons of comfrey. The plant is four or five feet high when near flowering, and the leaves attain a length of three feet. The flowers abound in honey. The solid stem is like a succulent root, and the plant is easily propagated by cuttings from this stem, containing a couple of eyes each. When once well rooted it will go on producing from fifteen to twenty years. The fodder may be cut six or even eight times a year; and if the leaves are stacked green, or partially dried, with a little salt between the layers, they keep well through the winter.

The Coat of the Rocky Mountain Sheep.—Western huntsmen who have chased the Rocky Mountain sheep, or big-horn (*Ovis montana*), generally believe that the animal wears only a coating of hair, never wool; but, in a communication to the *American Naturalist*, Dr. F. M. Endlich shows that this is an error, and that the big-horn varies in the nature of its covering according to the seasons, being clothed with hair in summer, and with wool in winter. On July 17, 1877, Dr. Endlich, while engaged in work connected with the survey of the Territories, found himself among the Wind River Mountains, at an elevation of 12,000 feet above sea-level, and amid large fields of snow. While contemplating the scenery around, he heard the sound of tramping feet, and, looking up, saw four mountain-sheep approaching, though at first he scarcely recognized the species. They were of a totally different color from any he had seen before, and seemed to have a very rough skin. Eight days later Dr. Endlich ascended a high peak in the same range, and, as he reached the timber-line, he saw a band of over a hundred big-horns. Some of these he shot and killed. The "hair" was shorter than usual. It was apparently growing rapidly, and pushing before it a layer of very fine wool, about half an inch in thickness. In other words, the sheep were shedding their wool, which is exceedingly fine, and of a light-gray color. Some portions of the body were already clear of it. This explained the peculiar color and appearance of the sheep seen a week previously.

New Method of annealing Glass.—A new method of annealing glass is proposed by Messrs. Albert and Weyer, of Paris. It consists in burying the articles to be annealed in powdered stone, plaster, lime, etc., or in grease, oil, melted nitrates of potash and soda, in short, in any liquid or solid capable of receiving the required heat, and remaining in a condition suitable for the process. By imbedding the articles in powder, they can be annealed at a very high temperature—a thing impossible unless some means are provided for supporting the objects and maintaining their shape when reduced to the softened state necessary to secure perfect annealing. By the new process the articles are filled with the powdered stone or other substance, and are then placed in crucibles and completely surrounded with the pulverized substance employed. They are then subjected to a heat gradually increasing to 200° Cent., or even 1,000° C. from four to six hours, and are then slowly cooled. When there is little danger of spoiling the shape of the articles, they can be annealed by the use of liquids and at less cost. In this case two boilers are employed, so placed that the liquid can be run from the upper into the lower. If nitrate of soda is employed, the temperature will be over 260° C. before the salt is melted, and the articles are then immersed in the cold state, and the temperature raised to 800° C. Then they are allowed to cool slowly, and when the temperature has fallen to nearly 260° C.—the solidification point—the nitrate is run off into the lower boiler, and a small fire is maintained beneath the upper boiler to prevent the too rapid cooling of the glass.

Influence of Chemical Research on Character.—Prof. Maxwell Simpson, President of Section B of the British Association, in his address makes some very judicious remarks on the influence of chemistry upon the intellectual habits and moral character of its cultivators. He first notes how the study of chemistry, or rather original chemical work, promotes accuracy, thoroughness, and circumspection. An organic analysis requires six weighings; if any one of these is inaccurate, the results are worthless. Unless the analyst is sure of every step in his research, his results are doubtful, and therefore of no value. Again, the original worker must be ever on his guard against error, and laboratory-work teaches us to use our senses aright, sharpens our powers of observation, and prevents us from reasoning rashly from appearances. Then, as regards the effect of original work on the character, in developing the virtues of courage, resolution, truthfulness, and patience: the chemist is often obliged to perform experiments which are attended with great danger, and no man can hope to fight long with the elements without carrying away many a scar. Sometimes fatal accidents occur. But the chemist must not be discouraged by fear of accident, neither must

he be disheartened by the temporary failure of his experiments, nor at the slowness of his processes. "Bunsen was obliged to evaporate forty-four tons of the waters of the Dürcheim springs in order to obtain two hundred grains of his new metal, cæsium. It took Berthelot several months to form, by a series of synthetical operations, an appreciable quantity of alcohol from water and carbon, derived from carbonate of baryta. Many years ago, in the laboratory of Wurtz, a poor student was carrying from one room to another a glass globe which contained the product of a month's continuous labor, when the bottom of the globe fell out, and the contents were lost. Nothing daunted, he recommenced his month's work, and brought his research to a successful issue. Above all things, the chemist must be *true*. He must not allow his wishes to bias his judgment or prevent him from seeing his researches in their true light. He must not be satisfied that his results appear true, but he must believe them to be true; and, having faithfully performed his experiments, he must record them faithfully. He may often be obliged to chronicle his own failures and describe operations that tell against his own theories, but this hard test of his truthfulness he must not shrink from."

A New Form of Galvanic Cell.—When rods of zinc and copper are placed in mercury, and connected with an electrometer, no change is observed; and, whether the zinc and copper are in contact outside the mercury or not, the amalgamation of the zinc appears to proceed at the same rate. According to a communication to the London Royal Society, from Profs. Ayrton and Perry, of the Tokio Engineering College, the impurities and great conductivity of the zinc, with the great liquidity of the amalgam, and the close proximity of foreign particles to pure metal, cause the amalgamation to be produced by local action alone, so that the supply of available chemical energy for the production of a current from the zinc to the copper is exceedingly small: at low temperatures, when the amalgam loses its liquidity, such an arrangement would, the authors conjectured, become a simple voltaic cell. To test this they substituted, for zinc, magnesium, whose amalgam is nearly solid at ordinary temperatures. Strips of platinum and magnesium, metallically attached to the electrodes of the electrometer, were dropped into mercury which had been washed with distilled water and then well dried. There was a sudden large deflection, afterward fluctuating very much, but keeping always on the same side of zero. On successive reversals of the electrometer key, the deflections to the right and left of zero were found to be nearly equal to one another. To determine the electro-motive force of the arrangement, strips of platinum and magnesium, scraped very clean, were dipped into pure mercury. The maximum electromotric force obtained was 1.56 volts—equal to one and a half time the electromotrive force of a Daniell cell. The authors remark that, by mechanical or other means, or by using another metal than magnesium, it may be possible to give constancy to this arrangement; and as its internal resistance is extremely small, the cell may be of great practical use for the production of powerful currents. As an amalgam may be easily separated into its components by distillation, such a cell might be kept in action for an indefinite time.

An Interesting Geological Question.—Though the Triassic rocks of New Jersey and the Connecticut Valley are commonly regarded by geologists as intrusive igneous rocks, the direct proof of their intrusive nature is not readily accessible. Indeed, some geologists have supposed that, so far from being intrusive, they were formed contemporaneously with the shales and sandstones amid which they occur, as a bed of igneous rock at the bottom of a shallow sea in which the stratified rocks were being deposited. But Mr. I. C. Russell shows, in the *American Journal of Science*, that these trap-rocks were forced out in a fused state among the sedimentary strata after the consolidation of the latter, and hence that they are more recent than either the rocks above or below them. The evidence of this he finds in a ravine on the western slope of the First Newark Mountain, directly west of Westfield, New Jersey. Here the trap-rock which appears in the bed of a little brook presents its usual characteristics of a hard, bluish,

crystalline rock, with a conchoidal fracture. In other places it swells up into bosses and rounded masses which are thrust up into the overlying rocks. The outside of these masses presents a scoriaceous or slag-like appearance; in the interior the cavities are filled with infiltrated minerals. For the first two or three feet above the trap the shales which rest directly on these igneous rocks have been intensely metamorphosed, and are scarcely to be distinguished from the trap itself. At a distance of six or eight feet above the trap the shales are still very much altered and filled with a great number of small spherical masses of a dark-green mineral, resembling epidote. Midway up the sides of the ravine, which is about thirty feet deep, the shales present somewhat of their usual reddish appearance, but are traversed by a great number of irregular cavities formed by the expansion of vapor while the rocks were in a semi-plastic condition. At a distance of twenty-five or thirty feet above the trap, the shales and sandstones are changed but slightly, if at all, from their normal condition. A bed of limestone from two to three feet in thickness, which is here interstratified with the shales and sandstones where it approaches the trap, is considerably altered and forms a mass of semi-crystallized carbonate of lime. All this furnishes indisputable evidence that the igneous rocks composing the First Newark Mountain were intruded in the molten state between the layers of the stratified rocks subsequent to the consolidation of the latter; and by analogy we are justified in extending this conclusion to all the trap ridges which traverse the Triassic regions of New Jersey.

Agricultural and Mineral Resources of Alaska.—The following notes on the mineral and agricultural wealth of Alaska we take from a communication published in the *Chronicle* of San Francisco. The Territory is as yet virtually unexplored, yet gold, silver, copper, graphite, lead, iron, sulphur, and coal, have already been found in sufficient quantity to pay for working the deposits. "Eight well-defined ledges of gold-bearing quartz have been prospected on Baronoff Island, close to the town of Sitka; their owners owe their discovery and partial development to the enterprise and energy of one Haley, who was formerly a soldier of the garrison that was stationed here. Haley began to utilize his gold discoveries about three years ago by quarrying out rock and crushing it in a common hand-mortar. By this primitive process he obtained money enough to support his family and pay the cost of a visit to Portland and San Francisco in search of capital to develop his mines. Little is known of that section of Alaska which lies back of the coast between Cross Sound—where the Alexander Archipelago, with its 1,100 islands, ends—and Prince William's Sound. On Prince William's Sound are several Indian villages, and several tracts of prairie-land which may be easily cultivated. Beyond this large inlet lies Kodiac and Cook's Inlet. As a fishing and agricultural district this is undoubtedly the best section of the whole Territory of Alaska. The climate is milder, the winters less severe, and the rainfall less, than in the southern counties of Scotland. Both on Kodiac and the shores of Cook's Inlet are large tracts of prairie-land, which now afford excellent pasture for cattle and sheep, and which can be easily cultivated for all the hardy vegetables, barley, and oats. Timber is abundant and easily accessible from the water. A large deposit of coal has been prospected, the quality of which is declared by Prof. Newberry to be fully equal to any coals found on the Pacific coast, not excepting those of Vancouver Island and Bellingham Bay. The Indians who come down to the head of the inlet report large deposits of native copper a short distance inland, and exhibit ornaments and utensils of the same. Lead of sufficient purity to be moulded into bullets is also found there. The waters literally swarm with fish; and it is safe to say that there is no district of country on the whole Pacific coast which offers so many advantages for the profitable establishment of fish-canning and fish-curing works. With a comparatively moderate investment of capital, exports of fish to the value of several millions of dollars annually may be sent from Cook's Inlet, which would pay a large profit to the owners of the works, and would support many thousand fishermen, laborers, and mechanics. Nothing but the power of monopoly has hindered Alaska's growth thus far."

A New Theory of the Flow of Sap.—In a new theory of the ascent of sap in trees, proposed by Joseph Böhm, the elasticity of the plant-cells plays an important part. When the superficial cells have lost through evaporation a portion of their water, they partly collapse under the action of the air-pressure; but, like elastic bladders, they tend to resume their original form. This they can do only by drawing in either air or water from without. But since moist membranes are but little permeable by air, the cells draw from the cells farther toward the centre a portion of their liquid contents; these in turn draw on the cells farther down, and so on down to the roots. The author illustrates his theory by an apparatus which represents a chain of cells. A funnel closed by a bladder represents the evaporating leaf; to it are connected below several glass tubes about two inches wide, closed at one end with a bladder, and joined together in series by means of thick caoutchouc tubes. As evaporation goes on, the membrane which closes the funnel-mouth is bent inward, and, when it has reached a certain tension, water is sucked into the funnel out of the cell next below, which covers its loss in the same way. Manometers connected with certain cells of the apparatus indicate the amount of suction at different heights.

NOTES.

Complaint is made in the newspapers that fish and fowl are dying by millions in different parts of the country, poisoned, it is supposed, by Paris-green. In the valley of the Connecticut Paris-green is freely used to destroy the potato-beetle, and the recent heavy rains have washed it into the rivers, together with untold millions of poisoned beetles. It may be doubtful whether the Paris-green suspended in the stream could destroy many fish, but there is little doubt that eating the poisoned beetles would prove fatal both to fish and fowl. "There is no reason advanced," says the Hartford *Courant*, "to explain the wide-spread destruction of fish more plausible than this, and it is a singular fact that sportsmen on land have complained of a fatality among birds, the same as fishermen do of the fatal effects upon fish. Quail have been found dead in various parts of the State, and there is no doubt that the death of the birds is due to agricultural poisoning."

According to a Pittsburg newspaper, Messrs. Gemill and Wampler, of McKeesport, at 10 P. M. of July 11th, while observing the planet Jupiter with a five-inch telescope, noticed on the eastern limb a dark round spot, just above the northern belt of the planet. Soon it moved rapidly westward, just touching the belt and passing off the face of the planet at 1.24 A. M. of the 12th. It had the appearance of a perfect sphere much larger than any of Jupiter's satellites, sharply defined, and intensely black. It could not have been a spot on the disk of Jupiter, for it passed over the face of the planet in three hours and nineteen minutes, while a spot would have taken five hours. Neither was it a satellite, or the shadow of one, for all the four Jovian satellites were in full view the whole time.

Dr. Hermann J. Klein, of Cologne, has discovered a new crater on the moon's surface, situated in the Mare Vaporum, a little to the northwest of the crater Hyginus. The new crater is nearly as large as Hyginus, and is a conspicuous object. Klein, though he had previously again and again observed the same region, had never seen this crater; neither had it been noticed by other selenographers. The inference would appear to be that volcanic action is still going on in the moon.

During a session of an educational committee, the Bishop of Gloucester in the chair, one of the members lamented the very imperfect education given to girls under the present system. "The fact cannot be denied, I fear," said the chairman, "but there is one consolation—the boys will never find it out."

A numerously-attended meeting, of persons of both sexes, was recently held in Indianapolis, Indiana, for the purpose of forming a cremation society. A committee was appointed to draft a constitution and by-laws.

It is a pleasing picture that Sir David Wedderburn draws of the social usages of the people of Japan—"a country where men never lose their temper, where women and children are always treated with gentleness, where common laborers bow and beg pardon of each other if they happen to jostle accidentally, where popular sports do not inflict suffering on the lower animals, and where cleanliness takes such a high rank among social virtues as to be carried almost to a ludicrous excess;" and their courtesy is "singularly free from servile or mercenary considerations."

Some twenty-five years ago the British Association for the Advancement of Science met in a certain cathedral town, and in the Geological Section a rather warm debate arose about the truth of the Mosaic account

of the Deluge. The dean of the cathedral stoutly defended Moses, but he was badly defeated by the geologists. The next Sunday he preached a sermon on the Deluge, and proved, to his own satisfaction at least, the absolute accuracy of the story in "Genesis." He thus had the last word, for, as he remarked afterward, "none of those fellows could answer him there!"

According to Mr. A. C. Ranyard, of the British Astronomical Society, maxima of sun-spots, though their average periods are 11.11 years, occasionally occur at intervals of 13 or 14 years. In one instance, in comparatively recent times, viz., 1788.1 and 1804.2—16.1 years elapsed, while between the *maxima* years 1829.9 and 1837.2 there was an interval of only 7.3 years. An examination of the records of sun-spots proves the irregularity in their appearance to be so great that only vague prognostications can be made as to the time of an approaching maximum; and what is true of periods of maxima is also true of periods of minima. M. Faye, too, in a communication to the Paris Academy of Sciences, shows that the two phenomena of sun-spots and magnetism are not related, as they have not the same period. According to Wolf, the sun-spot period is 11.11 years, while the declination period of the magnetic needle is, according to Lamont and others, 10.45 years.

While exploring the desert region east of the Lob-Nor, the Russian traveler, Colonel Prejevalsky, made inquiries of the natives concerning the existence of wild camels in that country, and learned from them that those animals were still to be found in the Kum-Tag Desert, which extends over three degrees of longitude from east to west (91°–94° east), and is bounded north and south by latitude 39° and 40° north. The wild camels in summer seek the upper valleys of the Altyn-Tag, a mountain-chain on the southern edge of the Kum-Tag, and retire into the most inaccessible deserts in winter. Their sight, hearing, and smell, are exceedingly quick, in striking contrast to the domesticated camel, in which these senses are very dull. Colonel Prejevalsky employed hunters to procure the skins of these animals, and three skins were brought to him, representing a male, a female, and a colt.

In Germany, according to the *Polytechnic Review*, sawdust is employed in the production of sundry articles both useful and ornamental. A plastic mass is prepared, composed two-thirds of hard-wood sawdust and one-third glue, resin, or other binding material. This is compressed in brass moulds, and the moisture driven out by heat. The articles made are bass-reliefs, piano-keys, door-knobs, brush handles and backs, etc.

The excessive "militancy" of the people of Montenegro is well illustrated by their estimate of the comparative values of male and female infants. If a man has a daughter born to him, he regards the event almost as a misfortune—at least as a sore disappointment; he goes and sits on his threshold with downcast eyes, as though begging pardon of his neighbors and friends! But if several daughters are born in unbroken succession, the mother must call in seven priests, who bless oil and sprinkle it about the house, remove the old threshold and put in a new one, thus purifying the house which was bewitched on the wedding-day. On the other hand, if a boy is born, the entire household is almost crazy with joy; a feast is spread, and friends and acquaintances come thronging in to offer their congratulations and to express the wish—so characteristic of the national spirit—that the new-born babe may never die abed!

Workmen employed in nail-manufactories are liable to contract a grave lung-disease known as "nailers' consumption," caused by the deposit of iron particles in the cells of the lungs. The best preventive of nailers' consumption is no doubt the use of a respirator, such as that contrived by Prof. Tyndall for the use of firemen. The respirator would exclude from the respiratory organs the minutest particles of solid matter; it is far more effectual than any of the other devices which have been proposed, such as moist sponges or false mustaches.

The exorbitant price demanded by the patentees of the Bell telephone for their instruments causes no little discontent in England, where that form of the telephone has the field to itself, so far as the law is concerned. It does seem rather extortionate to levy from twenty-five to thirty-five pounds sterling on the purchase of an instrument that could be sold with a profit for half as many shillings. The result is, that the patent is boldly infringed: the separate parts of the telephone are for sale everywhere at a low price, and so people are enabled to make telephones for themselves. It is not probable that the decrees of courts which seek to uphold so odious a monopoly can be enforced.

William Laidlaw, native of Congo, now a freedman living in the island of Dominica, was born with six fingers on each hand. He is the father of four children, two boys and two girls, each born with six fingers on the hands, one of the girls having also six toes on each foot. One of the sons is the father of two boys who have six fingers on each hand; and the five children of the other son were born with the same peculiarity. This family well illustrates the wonderful persistence of sedigitism.

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